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Selection of Customer Service Meters

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A paper presented on Oct. 3, 1946, at the New York Section Meeting, Albany, N.Y., by Samuel F. Newkirk Jr., Engr. & Supt., Board of Water Comrs., Elizabeth, N.J.

THERE are 28 different types of fluid meters, according to the A.S.M.E. classification, distributed under two divisions and eight classes, as shown in Table 1. In this discussion, however, only those types which are almost universally used in the water works profession for the measurement of supply to customers will be considered.

Basically, there are only two classes of meters used for general water customer service—the positive, volumetric type and the inferential, current (kinematic) type. Compound meters, both for service and fire service, are really combinations of these basic types.

Selecting Meter Types

Displacement meters, which are practically positive in action and carry over a fixed quantity of water for each cycle of operation, are by far the most used. Generally, this type should be used on all installations for which the maximum demand does not exceed 160 gpm.

The current meter, which registers flow by recording the revolutions of an impeller, set in motion by the force of the flowing water, has but little use in water distribution. Because of its low accuracy on small flows, its use is restricted to railroad standpipes, elevators, water carts, water motors, irrigation systems and other installations requiring free discharge and heavy service, with little probability of small rates of flow during day or night.

Compound meters combine a main meter of the current or displacement type, for measuring large flows, with a small, displacement type meter, for measuring small flows, in conjunction with an automatic valve mechanism. In the author's judgment, this is the correct instrument for measuring water when the demand varies between 160 gpm. and 1,000 gpm. For larger flows, a battery of compound meters should be used. Some operators favor a battery of displacement meters instead of a compound meter because of

the low accuracy during the "change-over" from the by-pass to the main unit of the compound meter. The selection of the proper size compound meter to a degree eliminates this objection.

The fire service meter is a compound meter in which a proportional type main unit, for measuring large flows, combines with a small displacement type unit, for measuring small flows, in conjunction with an automatic valve mechanism. This combination is designed to afford an unobstructed passage through the main meter when its valve is raised from the seat. The measurement of flow recorded on the main unit, through which only a relatively small portion of the total flow actually passes, is likely to be inaccurate unless care is taken to keep all parts of the meter clean and in the very best working condition. Fire service meters should never be used for general service.

TABLE 1

A.S.M.E. Classification of Fluid Meters

Division	Class	Type
	QUANTITY METERS	
1. Positive	1.1 Weighing	1.11 Weighers
		1.12 Tilting traps
	1.2 Volumetric	1.21 Tank
		1.22 Piston
		1.23 Disc
		1.24 Rotary
		1.25 Bellows
		1.26 Wet drum
2. Inferential	2.1 Current (kinematic)	2.11 Propeller
		2.12 Anemometer
		2.13 Turbine
		2.14 Helical
	RATE OF FLOW METERS	
	2.2 Head (kinetic)	2.21 Venturi
		2.22 Flow nozzle
		2.23 Thin plate orifice
		2.24 Pitot
		2.25 Centrifugal
		2.26 Friction
	2.3 Area (geometric)	2.31 Gate
		2.32 Orifice & plug
		2.33 Cone & disc
		2.34 Cylinder & piston
	2.4 Head-area (weir)	2.41 Rectangular notch
		2.42 Triangular notch
		2.43 Special notch
	2.5 Force	2.51 Hydrometric pendulum
		2.52 Vane
	2.6 Thermal	2.61 Electric

Selecting Meter Sizes

The selection of the correct type of meter is relatively easy, but the determination of the proper size is complicated and requires careful calculation, coupled with experience and practical knowledge. The size depends largely upon the expendable pressure available, and may be determined by learning the maximum demand and permissible pressure loss and by referring to a capacity curve of the meter to be used.

To estimate the maximum demand before service for many establishments, one can refer to any of the standard plumbers' manuals, in which the required capacity for various fixtures is given in gallons per minute and the probability of simultaneous operation is estimated. Table 2, taken from a handbook published by the Copper & Brass Research Assn., offers an example of such capacity estimations.

TABLE 2

Rates of Flow Required by Plumbing Fixtures

FIXTURE	FLOW *gpm.*
Bath	8–10
Lavatory	5– 8
Tank closet	3– 5
Flush valve closet	30–40
Shower	5– 8
Sink	8–10
Laundry tub	8–10
Garden hose	5–10

The rate of flow may be approximated, as a rule, by dividing by four the amounts given in Table 2 for residences, apartments, schools, office buildings and other buildings in which the character of water consumption is similar. For clubs and hotels, the amounts should be divided by three; for gymnasiums, hospitals, public comfort stations and other such institutions, by two; and for public baths,

laundries and factories, the full amount should be allowed. Often special indications will require that different factors be used. At best, all these factors are arbitrary.

As an alternative, the method of calculating the maximum demand outlined by the National Bureau of Standards may be used. The essentials of this outline consist of a table of demand weights for different plumbing fixtures and curves from which the estimated demand in gallons per minute corresponding to any total number of fixture units may be obtained. The demand weights, presented in terms of fixture units for different plumbing fixtures under different conditions of service, appear in Table 3. The estimate curves for demand load are shown in Fig. 1 and 2. The curves marked *A* are for systems in which flush valves are predominant; those marked *B* for systems in which flush tanks are predominant.

TABLE 3

Demand Weights of Fixtures in Fixture Units *

Fixture† or Group	Occupancy	Type of Control	Weight in Fixture Units‡
Water closet	Public	Flush valve	10
Water closet	Public	Flush tank	5
Pedestal urinal	Public	Flush valve	10
Stall or wall urinal	Public	Flush valve	5
Stall or wall urinal	Public	Flush tank	3
Lavatory	Public	Faucet	2
Bathtub	Public	Faucet	4
Shower head	Public	Mixing valve	4
Service sink	Office, etc.	Faucet	3
Kitchen sink	Hotel or restaurant	Faucet	3
Water closet	Private	Flush valve	6
Water closet	Private	Flush tank	3
Lavatory	Private	Faucet	1
Bathtub	Private	Faucet	2
Shower head	Private	Mixing valve	2
Bathroom group	Private	Flush valve for closet	8
Bathroom group	Private	Flush tank for closet	6
Separate shower	Private	Mixing valve	2
Kitchen sink	Private	Faucet	2
Laundry trays (1–3)	Private	Faucet	3
Combination fixture	Private	Faucet	3

* Supply outlets likely to impose continuous demands should be estimated separately and added to the total demand of the fixtures.

† Weights of fixtures not listed may be assumed by comparison with one using water in similar quantities and at similar rates.

‡ For total demand. Weights of the maximum separate demands of fixtures with both hot and cold water supplies may be taken to be $\frac{3}{4}$ of the demand listed for the supply.

One progressive water department has developed a set of graphs used to determine the size of service connections and meters (1). With the number and type of fixtures known,

the probable maximum demand may be estimated. The total length of the service pipe may then be ascertained and the proper size of the service connection and meter determined from the graphs.

Any estimation of the demand of manufacturing establishments must include the quantity required by the manufacturing processes. This information can usually be obtained from the customer or the manufacturer of the equipment installed.

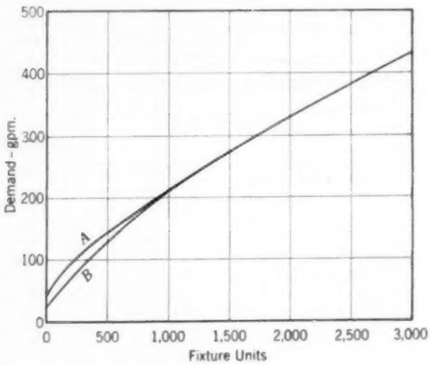

Fig. 1. Graph for Estimation of Demands
A—Flush valves predominant in system.
B—Flush tanks predominant in system.

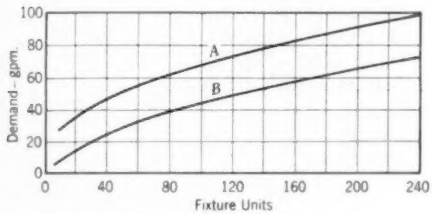

Fig. 2. Enlargement of Section of Fig. 1

TABLE 4

Rated Delivery of New York City Meters *

Size of Meter	Rated Delivery	
in.	*gpm.*	*mil.gal. per year*
	Displacement Meters	
5/8	2.0	1.1
3/4	3.4	1.8
1	5.3	2.8
1½	10.0	5.3
2	16.0	8.4
3	31.5	16.6
4	50.0	26.3
6	100.0	52.6
	Current Meters	
1½	10.0	5.3
2	17.5	9.2
3	40.0	21.0
4	70.0	36.8
6	160.0	84.1
8	280.0	147.2
10	437.5	230.0
12	640.0	336.4

* The load factor of compound meters is determined for each unit separately, and not for the meter as a whole.

TABLE 5

Rated Delivery Used by Hazen

Displacement Meters

Size of Meter	Rated Delivery	
in.	*gpm.*	*mil.gal. per year*
5/8	7.11	3.74
3/4	12.09	6.36
1	21.33	11.22
1½	42.67	22.44
2	71.70	37.40
3	142.20	74.81
4	213.30	112.21
6	426.70	224.42

Checking Meter Sizes

Whether a meter already in service is of the proper size may be ascertained by attaching a recording mechanism to the meter and obtaining data on maximum and average demand rates.

Another very useful method for determining whether the meters in a water system are of the proper size is to establish a load factor for the meters and let the regular meter readings show whether a meter is under- or overworked. A load factor, based on the permissible loss of pressure through the meter, has to be estab-

lished for each community and sometimes for separate districts within a community, if the pressure variations are large. The load factor is the ratio of the average delivery to the rated delivery. The rated delivery must not be confused with the manufacturer's rating or the safe operating capacity of the meters, as such quantities are based on too great a pressure loss (15–20 psi.).

New York City uses a rated delivery based on a 0.25-psi. loss, and, if the load factor is below 30 per cent of the rated delivery shown in Table 4, the meter is considered too large; if above 50 per cent, too small. Allen Hazen (2) uses a rated delivery based on a 5-psi. loss, and considers the meter to be underworked if the load factor is 2 per cent or less. Table 5 shows the rated delivery used for the calculation of the load factors.

Reference

1. SMITH, MARSDEN C. Standards for Water Service. W.W. & Sew., **21**: 191 (1944).
2. HAZEN, ALLEN. *Meter Rates for Water Works.* John Wiley & Sons, New York (1918).

Housing Expediter Priorities Regulation 7

Priorities Regulation 7 of the federal Housing Expediter, which became effective February 17, is of particular interest to water works men in that it provides for the sale and removal of aboveground and subsurface utilities located on land owned by or leased to the federal government. Thus, at long last, provision has been made for the expeditious transfer of utility properties located primarily on Army and Navy installations which have been inactivated since the cessation of hostilities.

Through the establishment of a new priority group of VEHP (Veterans Emergency Housing Program) self-certifiers, who have preference above the general public but below the groups prescribed by the Surplus Property Act, and through the simplification of certification procedures for utilities and structures in place, the new regulation is expected to facilitate the rapid sale of utility properties to the buyers who most need and can best use them. Since water utilities are included in the new priority group, water works executives, particularly in the Southwest and on the West Coast, where most of the facilities are located, will want to get in touch with their regional National Housing Agency or War Assets Administration offices for detailed information and assistance in establishing eligibility. It is suggested too that interested parties arrange to have their names placed on the WAA mailing lists to receive advance notice of sales of such properties.

Contemporary Chlorination Practices

By Harry A. Faber

A paper presented on Nov. 16, 1946, at the Wisconsin Section Meeting, Green Bay, Wis., and on Nov. 22, 1946, at the Joint Meeting of the Florida and Cuban Sections, Havana, Cuba, by Harry A. Faber, Research Chemist, The Chlorine Institute, Inc., N.Y.

WATER chlorination practice has evolved, during the past fifty years, from a relatively crude application to a highly efficient one. Such a steady process of progressive change is characteristic not only of this practice, but of all applications of scientific knowledge. The results of chlorination can be evaluated on the basis of the chemical and bacteriological results which have been accomplished by its use, and, for this purpose, it will be helpful to review briefly the history (1) of this method of water treatment.

Historical Summary

"Every decade," Dr. Max Thorek once said, "marks a distinct advance in science and art, reflecting the current history and progress of that particular period." The first decade (1896 to 1906) of chlorine's history as a method of water treatment witnessed the experimental use of chlorination and the inception of this method of treatment for continuous application. The earliest use of chlorine for water disinfection appears to have been by William M. Jewell in 1896, utilizing chlorine gas (produced electrolytically in small cells) in the experimental filtration studies conducted at Louisville, Ky. Three years later, at Adrian, Mich., Jewell again experimented with chlorine gas and then used chlorinated lime for temporary treatment of the effluent of full-scale filters. Chlorination of water, as a continuous treatment, was first adopted at Middlekerke, Belgium, where Dr. Maurice Duyk introduced the use of chlorinated lime in 1902, and where its use was continued until 1921. The second continuous use of chlorination was in England, where, in 1905, Sir Alexander Houston and Dr. McGowan started the application of sodium hypochlorite to disinfect the raw water supplying the Lincoln slow sand filters of the London system.

The second decade (1906 to 1916) was one of application. Following the first technically successful adoptions of chlorinated lime for water disinfection in North America—at the Bubbly Creek filtration plant of the Chicago stock yards and at the Boonton supply of Jersey City, N. J., in 1908—the application of this treatment grew rapidly. Midway through this period, the application of gaseous chlorine became practical, and, as improvements were made in chlorinating equipment, liquid chlorine steadily replaced chlorinated lime for the disinfection of water.

The third decade (1916 to 1926) was one of method. The chlorine demand of waters was found to be highly variable, and it came to be recognized that satisfactory chlorination could be obtained, not by a specific dosage, but by the residual which was provided. Ortho-tolidine had been proposed as an

indicator for residual chlorine in 1909, and colorimetric standards for its use were developed in 1913. Its application as an important and practical control test for the chlorination of water supplies did not begin until 1918, but its use spread rapidly thereafter. Super-chlorination was studied in 1925, as a means of removing tastes and odors from water, and was put into operation the following year.

The fourth decade (1926 to 1936) was one of action. Chlorination became general practice for treatment of even the smallest water supplies. Chlorine-ammonia treatment, which was found to provide a more persistent residual than chlorine alone and to limit the development of many objectionable chlorinous tastes, was widely adopted.

The fifth decade (1936 to 1946) has been one of refinement. It has been distinguished by important studies of the fundamental factors which affect the action of chlorine in water and by the development of improved chlorination control measures. A new concept of chlorination practice has resulted from these refinements and has been put into practical application.

Reactions of Chlorine

In these five decades of development, much has been learned and published concerning chlorine application and the process of chlorination employed. As might be expected, a loose terminology has come into use during this period. The serious need for clear definitions of terms has been recognized by a committee of the American Water Works Association (1), and the following discussion is based largely on the terminology proposed by the committee.

Chlorine reacts with water to form hydrochloric acid and hypochlorous acid. The hypochlorous acid ionizes or dissociates into hydrogen ions and hypochlorite ions. Both reactions are dependent upon the pH value of the water, the first reaction predominating at low pH values and the second at high pH values:

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$
$$HOCl \rightarrow H^+ + OCl^-$$

When chlorine is added to water, therefore, a portion of it may be present as molecular chlorine (Cl_2), as hypochlorous acid (HOCl) or as hypochlorite ion (OCl^-), and may be designated as *free available chlorine*.

The chemical activity of chlorine is a function of its capacity to combine with organic matter and to oxidize or supply oxygen to reducing substances. The intensity with which any oxidizing agent enters into chemical reaction is measured by its oxidation potential. Chemical reactions that occur when chlorine is added to water, and the rate at which they proceed, are dependent upon the oxidation potential of the free available chlorine.

When chlorine combines with other substances, its oxidation potential is reduced or may be completely neutralized. Chlorine reacts with ammonia to form chloramines and with other organic nitrogen compounds to form chloro-derivatives. With many forms of organic matter, particularly the hydrocarbons, chlorine addition products are formed. Those chlorine compounds lower in oxidation potential than free available chlorine may be designated as *combined available chlorine*.

Chlorine demand is defined as the difference between the amount of chlorine added to water and the amount of residual chlorine remaining at the end

of a specified contact period. The chlorine demand expresses a definite equilibrium of the chemical reactions of chlorine in water under known conditions. For any water it will vary with the amount of chlorine applied, the time of contact and the temperature.

When a small dose of chlorine is added to water it combines with organic substances to form addition and substitution compounds. The residual remaining is predominantly combined residual chlorine. As larger amounts of chlorine are added to water, in order to obtain a higher residual, the chlorine demand will be increased and the residual remaining may include some free available chlorine.

When water receives a dose of chlorine sufficiently large to produce a definite residual in which free available chlorine predominates, the oxidation potential will be increased to such a degree that oxidation reactions will prevail. Instead of combining with organic substances, usually to form compounds having undesirable tastes and odors, the chlorine may oxidize these substances. Oxidation frequently will destroy such substances or change them to other and less complex compounds, with the resulting removal of disagreeable tastes and odors.

Chlorine Residuals

That chlorination can provide an effective safeguard against the transmission of water-borne diseases has been well established. During recent years, however, it has become increasingly evident that a false sense of security may result from the maintenance of chlorine residuals which are inadequate in quantity or quality. Suitable control measures must be used if the application of chlorine for disinfection and other purposes is to be successful.

For many years, the control of chlorination has been accomplished by applying an amount of chlorine sufficient to produce a chlorine residual in the treated water. Only recently have practical methods been devised to differentiate, in the composition of a chlorine residual, between combined available chlorine and free available chlorine. Present methods enable the production of a chlorine residual of known composition by suitable control of the chlorination process. It should be recognized, therefore, that the term, "a chlorine residual," is vague and no longer adequate.

The terms, "a combined available chlorine residual" and "a free available chlorine residual," are specific and constitute a new basis for distinguishing between various chlorination practices. All chlorination practices may be classified as one of these two types, whatever the point of chlorine application or the process of chlorination employed.

When a combined available chlorine residual is desired, the characteristics of the water will determine whether it can be produced by the application of chlorine alone, of the chlorine-ammonia process or of ammonia alone. If the water always contains sufficient free ammonia to maintain a combined available chlorine residual of the desired magnitude, then the application of chlorine alone will be required. If the water contains no ammonia, or too little to maintain a combined available chlorine residual of the desired magnitude, then chlorine-ammonia treatment is indicated. If the water contains free available chlorine and it is desired to convert this residual to combined available chlorine, then the application of ammonia will be necessary.

When a free available chlorine residual is desired, the characteristics of the water will determine whether it can be produced by applying chlorine alone, by the break-point process or by the super- and de-chlorination process. If the water contains no free ammonia, the application of chlorine alone will be required. If the water contains sufficient free ammonia to result in the formation of a combined available chlorine residual, then the break-point process or the super- and de-chlorination process will be required.

The efficiency of disinfection is a function of the composition of the chlorine residual, without regard to the chlorination process which is employed to produce it. The composition of the chlorine residual, therefore, provides the most suitable criterion for the classification of chlorination practices. On this basis, therefore, all modern practices should be identified either as "combined residual chlorination" or as "free residual chlorination."

Mechanism of Chlorination

Combined residual chlorination is defined as the application of chlorine to water to produce with the natural or added ammonia a combined available chlorine residual, and to maintain that residual through part or all of a water treatment plant or distribution system. A combined available chlorine residual should contain little or no free available chlorine and should not be confused with a false residual—that is, one due to ferric iron, manganic manganese or nitrites.

When water is chlorinated, the free available chlorine (which has a high oxidation potential) reacts rapidly with any oxidizable substances present. If the water contains natural or added ammonia, combined available chlorine (which has a low oxidation potential) is formed, and the rate of reaction with oxidizable substances is decreased. The low oxidation potential of combined available chlorine, compared with free available chlorine, accounts also for its slower bactericidal action. Data have been published to show that to obtain equivalent bactericidal action requires, with the same period of exposure, about 25 times as much combined available chlorine residual as free available chlorine residual; or, with the same amount of residual, a contact period about 100 times as long for the combined available chlorine residual as for the free available residual.

The chlorine-ammonia process is defined as the application of chlorine and ammonia to water, or of ammonia to water containing chlorine, to provide combined residual chlorination. Combined residual chlorination, produced by the chlorine-ammonia process, cannot be considered a satisfactory means for the disinfection of all water supplies or a corrective for all taste and odor problems; often it does not accomplish satisfactory results. Each problem must be studied separately to determine the efficiency of this process.

Free residual chlorination is defined as the application of chlorine to water to produce, directly or through the destruction of ammonia, a free available chlorine residual, and to maintain that residual through part or all of a water treatment plant or distribution system. A free available chlorine residual should contain little or no combined available chlorine and should not be confused with a false residual.

At low pH values, free available chlorine residuals are composed largely of hypochlorous acid ($HOCl$). Above pH 7.5, the hypochlorite ion (OCl^-) predominates; and, above pH 9.5, free

available chlorine residuals consist almost entirely of hypochlorite ion. The bactericidal effect of hypochlorous acid is more rapid than that of the hypochlorite ion.

When free residual chlorination is employed for the pre-chlorination treatment of waters having a pH value below 9.5, it can solve many plant problems in addition to disinfecting the supply. With adequate contact time, this practice can be applied for the oxidation of ammonia, iron, manganese and protein substances in the water. Removal of the oxidized iron, manganese and some protein substances can be effected in part by coagulation and settling, and in part by filtration.

In general, the break-point process will be selected for free residual chlorination when a long contact period is available, and the super- and de-chlorination process will be selected when only a short contact period is available. All the chemical reactions of chlorine follow the law of mass action. Thus, the concentrations of chlorine and of oxidizable substances govern the rate and the completeness with which oxidation proceeds.

The *break-point process* is defined as the application of chlorine to water containing free ammonia to produce free residual chlorination. The amount of chlorine applied must be sufficient to provide, immediately or within the detention time available in the treatment plant, a free available chlorine residual that is at least 90 per cent of the composition specified.

The *super- and de-chlorination process* is defined as the application of chlorine to water to produce free residual chlorination in which the free available chlorine residual is so large that dechlorination is required before the water is used. This process, as now defined, is a *controlled* chlorination practice. It may be employed, where no other chlorination process will accomplish the desired result, to attain the maximum rate of bactericidal action and of taste and odor reduction. De-chlorination can be accomplished by applying reducing agents, such as sulfur dioxide and its derivatives (sodium sulfite and sodium bisulfite), by using granular or powdered activated carbon and by submerged or spray aeration to volatilize a part of the residual chlorine.

Control of Chlorination

One of the most important contributions to the development of any science is the improvement in applied methods of measurement. This is especially true in the treatment of water with chlorine, because the results obtained by chlorination are not directly visible but must always be studied and measured indirectly.

The records show (2) that Dr. Maurice Duyk utilized starch-iodide titrations to control the first continuous application of chlorination in 1902. Earle B. Phelps (3), in 1909, conceived the use of ortho-tolidine as a reagent for the detection of residual chlorine in water and, in 1913, Ellms and Hauser (4) developed colorimetric standards to make this a quantitative determination. Only when Wolman and Enslow (5) demonstrated, in 1918, the suitability of the ortho-tolidine test for even the smallest supplies, however, did its application become widespread. This test met a definite need, enabling non-technical plant operators to regulate the addition of chlorine on the basis of a desired residual.

The ortho-tolidine test is simple and of sufficient accuracy, except for two limitations: it does not distinguish adequately between residual chlorine

and certain interfering substances which may be present in the water; and it does not distinguish adequately between the forms in which residual chlorine may be present in the water. For thirty years, following the development of this test, many investigators have attempted to devise refinements of the ortho-tolidine test or to develop new tests employing other indicators.

With increasing contamination of water supplies, consumers frequently found chlorinated water to possess a chlorinous, chloro-phenolic or medicinal taste. In order to limit the production of objectionable tastes, the amount of chlorine applied was frequently reduced below the dose necessary for dependable disinfection; many waterborne epidemics have been traced to such undertreatment. The chlorine-ammonia process, the super- and dechlorination process and the breakpoint process represent practices developed to meet the need for treatment methods that would provide a palatable water and still give a high degree of disinfection. Throughout this period, the need for an improved method of residual chlorine determination became even more pronounced.

In 1944, F. J. Hallinan (6) proposed a simple modification of the standard ortho-tolidine test that employs only one additional reagent, a dilute solution of sodium arsenite, and enables the measurement of free available chlorine, combined available chlorine and interfering substances in water. Gilcreas and Hallinan (7) have studied the practical use of this test and report it fully applicable to plant and field conditions. The simple procedure of the ortho-tolidine-arsenite (OTA) test provides the best method at present available for the control of chlorination. The "flash test" procedure using standard ortho-tolidine solution, developed by Laux (8) in 1940, has provided an extremely useful qualitative test for free available chlorine residuals. It is especially applicable as a plant control method, except when oxidized manganese is present in the water. These tests are included in the current edition of *Standard Methods.* (9).

The development of modern water chlorination practices and precise control methods is a tribute to many capable investigators. Their research has resulted in a clear understanding of the chemistry of chlorination. The new terminology proposed should materially assist better application of chlorination processes and more satisfactory interchange of information.

Contemporary Practices

The theoretical considerations of yesterday become the plant practices of today. Frequently, in fact, the practical application of chlorination has even preceded an understanding of the fundamental principles involved. During the last few years the technical literature has provided many examples of new or improved uses for chlorine that depend upon its bactericidal effects, its chemical effects or its utility for special purposes.

Bacterial Effects

To meet the current standards of water quality recommended by the U. S. Public Health Service and accepted by the American Water Works Association (10), or to attain even higher standards of bacterial quality, Baylis (11) suggests the complete elimination of all lactose-fermenting organisms. Streeter (12), as a result of extensive laboratory studies of chlorination practice, concludes that it is desirable to maintain a free available chlorine resid-

ual of at least 0.2 ppm. through the entire water distribution system.

In a survey of practices followed in several Indiana treatment plants, Adams (13) shows that lactose-fermenting organisms can be completely eliminated when the turbidity of finished water is below 0.3 ppm. and free available chlorine residuals are maintained. Wilson (14) has demonstrated at Fredericksburg, Va., that free residual chlorination can produce a finished water free from coliform organisms and also provide a stable residual which persists through an open reservoir far into the distribution system. Water free from lactose-fermenting organisms is also produced at Waterford, N.Y., where Yaxley (15) reports the addition of ammonia to finished water carrying a high residual of free available chlorine; while residuals ranging from 3.0 to 7.0 ppm. are maintained in the distribution system, there are no complaints of taste or odor in the hot or cold water.

Chlorination may have very useful applications to control the growth of bacteria even before water reaches the treatment plant. Jackson and Maynan (16) show that free residual chlorination has eliminated growths of slime organisms which seriously decreased the carrying capacity of an important raw water supply line at Little Rock, Ark. Treatment of well waters in California by super- and de-chlorination, to remove hydrogen sulfide and control the growth of iron and sulfur bacteria, is reported by Alexander (17) to be very successful.

In a small water treatment plant at Beckley, W.Va., Chandler (18) has found free residual chlorination effective in reducing color, iron and manganese ahead of filtration. At Wheeling, W.Va., excessive pollution of a river supply makes the treatment problem very difficult, but Todd (19) reports that any concentration of phenols can be removed by chlorination and a free available residual provided.

In the distribution system, successful control of bacterial corrosion, by residuals of combined available chlorine and of free available chlorine, is described by Thomas (20). Troubles due to iron bacteria have been corrected by Grove (21), using combined residual chlorination. Griffin (22) reports that the growth of slime-forming organisms can be controlled by free residual chlorination.

Chemical Effects

The control of tastes and odors through the maintenance of free available chlorine residuals has been reported from many water treatment plants. At Houston, Tex., where chlorine is employed for this purpose and where ammonia is used to de-chlorinate the treated water partially, Harvill (23) notes that free chlorine residuals are more stable than combined chlorine residuals. The maintenance of a "chlorine blanket" throughout a reservoir at Baltimore, Md., is described by O'Brien (24) as accomplishing complete control of algae growths and accompanying turbidity.

Phillips (25), at Durham, N.C., reports that the removal of manganese can be accomplished by the use of iron coagulants aided by free residual chlorination. The oxidation of iron and manganese at Olean, N.Y., is credited by Fuller (26) with resulting in marked lengthening of filter runs. At Ottumwa, Iowa, Poston (27) has developed an efficient technique using chlorine to remove mud balls from filters and to maintain filter sand in excellent condition.

Special Uses of Chlorine

Among many special uses, chlorine has been found effective for the sterilization of new and repaired water mains (28), and for the emergency disinfection of mains and of water supplies (29). It is used for the disinfection of deep wells (30) and is being employed more generally for restoring the capacity of wells (31, 32). A relatively new method of treatment, the use of chlorine to prepare chlorine dioxide, is proving successful for a number of taste and odor control purposes (33, 34).

Future of Chlorination

If the past may be used as a guide to the future, water chlorination practices will continue to develop into applications of increasing utility. It is already possible to witness the more general adaptation of photoelectric colorimeters and residual chlorine recording devices for greater precision in controlling the application of chlorine. It is to be hoped that chlorination continues to be influenced by developments in all fields of knowledge, until "every decade marks a distinct advance" in the future of this practice.

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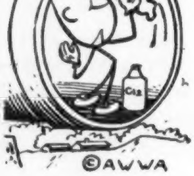


Ortho-tolidine Titration Procedure for Measuring Chlorine Residuals

By C. H. Connell

A paper presented on Oct. 16, 1946, at the Southwest Section Meeting, Galveston, Tex., by C. H. Connell, Assoc. Prof. of Sanitation, University of Texas Medical Branch, Galveston, Tex.

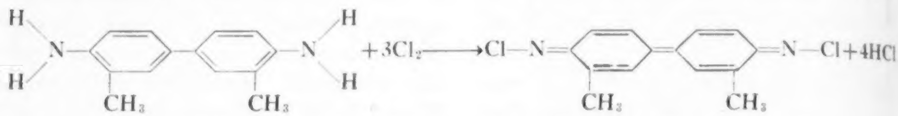
TITRIMETRIC measurement of chlorine residuals by means of ortho-tolidine solution was first employed by the author in 1943. It was not observed until 1945, however, that the method was specific for free available chlorine. At that time a simple field kit was developed which received limited distribution to field military personnel on the islands of Oahu and Okinawa. Recently a thorough study has been made of the chemical and color reactions involved, and a procedure has been developed which compares favorably with other methods for measuring free available chlorine.

The procedure is a simple titration method requiring two chemicals (dilute hydrochloric acid for acidification and standard ortho-tolidine solution as titration reagent) and using the simplest pieces of volumetric apparatus. Measurement of free available chlorine can be made quickly and with sufficient accuracy for control of free residual chlorination under most conditions ordinarily encountered. Nitrite nitrogen, ferric iron and manganic manganese produce no interference and chloramines, no significant interference. Turbidity as high as 300 to 400 ppm. causes no serious difficulty in reading the titration end-point. The procedure is as specific for free available chlorine residuals as the ortho-tolidine-arsenite method (1, 2) and affords greater accuracy in measurement of high residuals. It also has the advantage of being applicable to samples at any temperature ordinarily encountered in chlorination of water, whereas it is necessary to have the temperature of the samples at or below approximately 60°F. for the ortho-tolidine-arsenite procedure. No apparatus has been available for making comparison tests with the amperometric titration procedure (3, 4). Experience with the ortho-tolidine titration method, however, indicates that it affords measurement of free available chlorine with precision approaching that obtainable by the amperometric method.

Chemical and Color Reactions

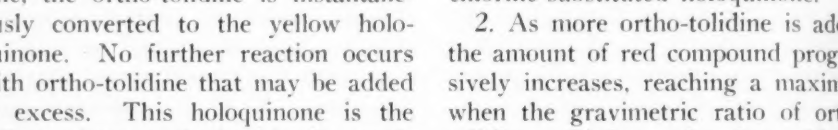
The ortho-tolidine titration of free available chlorine is based upon two reactions that occur between ortho-tolidine and chlorine in acidified samples (pH below 1.8) at different concentration ratios of the two materials. These and other reactions between ortho-tolidine and chlorine are discussed in detail by Griffin and Chamberlin (5). When one-third mol of ortho-tolidine is added to an acidified sample containing 1 mol of free available chlorine, the ortho-tolidine is in-

stantaneously converted to the chlorine-substituted holoquinone. This produces, in high concentrations (equivalent to chlorine concentrations in excess of approximately 3 ppm.), a cherry red color, but only a light amber to red amber color in lower concentrations. The ratio of one-third mol of ortho-tolidine to 1 mol of chlorine gives a gravimetric ratio of 1 : 1. The chemical equation representing the reaction in the formation of the chlorine-substituted holoquinone is:



Ortho-tolidine + Chlorine——→Chlorine-Substituted Holoquinone (red)

When 1 mol of ortho-tolidine is added to an acidified sample which contains 1 mol of free available chlorine, the ortho-tolidine is instantaneously converted to the yellow holoquinone. No further reaction occurs with ortho-tolidine that may be added in excess. This holoquinone is the yellow substance obtained in the standard ortho-tolidine colorimetric test for total available chlorine residuals. The ratio of 1 mol. of ortho-tolidine to 1 mol. of chlorine gives a gravimetric ratio of 3 : 1. The equation representing the formation of the yellow holoquinone of ortho-tolidine is:



Ortho-tolidine + Chlorine——→Holoquinone of Ortho-tolidine (yellow)

Chloramines also react with ortho-tolidine in acidified samples to form the chlorine-substituted red holoquinone and the yellow holoquinone, but the reactions are much slower than the reactions of free chlorine with ortho-tolidine. The production of the red compound by chloramines is sufficiently slow and incomplete to produce no appreciable interference with the titration of free chlorine in the presence of chloramines.

When ortho-tolidine is added to an acidified sample containing free chlorine, as in a volumetric titration, the chemical and color reactions progress as follows:

1. At the introduction of the first drop or two of ortho-tolidine, a light amber or light orange color * is produced instantaneously, due to the formation of a small amount of the red chlorine-substituted holoquinone.

2. As more ortho-tolidine is added, the amount of red compound progressively increases, reaching a maximum when the gravimetric ratio of ortho-tolidine added to the free chlorine present reaches or slightly exceeds 1 : 1. This point of maximum red color is difficult to recognize and therefore does not make a satisfactory end-point for the titration. In samples containing less than approximately 2 ppm. of chlorine, the maximum red color is

* In samples containing more than approximately 1 ppm. of chlorine, this light amber color will fade unless more ortho-tolidine is added immediately. A secondary and chlorine-consuming reaction occurs between the small amount of ortho-tolidine and the large excess of free chlorine.

scarcely more than an orange or a red amber. At chlorine concentrations above approximately 3 ppm., the maximum red color is a cherry red.

3. As ortho-tolidine is added beyond the gravimetric ratio of 1 : 1 and approaches the 3 : 1 ratio, the red compound is progressively converted to the yellow holoquinone, and the color changes from the point of maximum redness, approaching yellow. The point at which there is no further change toward yellow marks the point at which the 3 : 1 ratio has been reached, and is the end-point of the titration. The addition of more ortho-tolidine produces no further change in color.

Titration of 0.3–4.0 ppm. Residuals

The following technique is recommended for measuring free available chlorine residuals from 0.3 ppm. up to approximately 4 ppm.:

1. Transfer a 333-ml. portion (330–336 ml.) of the sample to a 500-ml. Erlenmeyer flask (a wax pencil calibration mark on the flask at 333 $\pm$ 3 ml. affords adequate accuracy for measuring the sample).

2. Acidify by adding approximately 1 ml. of 6*N* HCl.

3. Using a burette or measuring pipette, add one or two drops of standard ortho-tolidine solution and mix. If a light orange or light amber color appears within 2 to 4 seconds, continue immediately and rapidly adding the reagent and twirling the flask until the change in the direction of red reaches a maximum. Then add the reagent at a slightly slower rate until all the red disappears and there is no further color change in the direction of yellow. This is the end-point of the titration. The number of milliliters of standard ortho-tolidine solution required gives directly the parts per million of free available chlorine in the sample.

4. The results from a first titration of samples having residuals higher than 1 ppm. may be slightly inaccurate, due to slow addition of the reagent at the beginning or to difficulty in recognizing the end-point color change. Approximately 1 ml. excess of ortho-tolidine can be added beyond the estimated end-point and this color used as an end-point comparison for additional titrations of portions of the same sample. In these subsequent titrations, the first $\frac{1}{3}$ to $\frac{1}{2}$ of the total ortho-tolidine required should be added as rapidly as the titration pipette or burette will flow. The titration should then proceed with moderate rapidity until the color matches the color comparison control.

Very Low or High Residuals

For exact measurement of free chlorine residuals below approximately 0.3 ppm. it is necessary to use samples of larger volume and/or ortho-tolidine of lower strength. For proper pre-acidification of the sample, approximately $\frac{1}{3}$ ml. of 1 : 1 hydrochloric acid per 100 ml. of the sample should be used. Convenient volumes of samples and strength of ortho-tolidine are 1-liter samples with standard ortho-tolidine or 333-ml. samples with ortho-tolidine solution at one-third standard strength. Either procedure will make 1 ml. of ortho-tolidine represent 0.33 ppm. of chlorine.

For measuring chlorine residuals above 4 ppm. and up to approximately 15 ppm., 100-ml. samples can be titrated with ortho-tolidine solution of standard strength. The addition of ortho-tolidine up to the approximate mid-point of the titration should be very rapid. For titration of samples

TABLE 1

Precision and Comparison Tests on Samples Containing No Combined Available Chlorine

Test Number	1	2	3	4	5	6
	ppm.					
Approximate Free Chlorine	0.3	0.7	2.0	4.0	10.0	20.0
Ortho-tolidine Titrations						
Maximum reading	0.35	0.67	2.20	2.85	10.0	19.4
Minimum reading	0.30	0.63	2.00	3.70	9.65	18.9
Average reading	0.32	0.64	2.09	3.78	9.75	19.2
Maximum variation	0.05	0.04	0.20	0.15	0.35	0.5
Acid Iodimetric Titrations						
Maximum reading	0.41	0.67	2.15	3.85	9.65	19.1
Minimum reading	0.34	0.64	2.10	3.70	9.30	18.8
Average reading	0.38	0.65	2.13	3.75	9.50	19.0
Maximum variation	0.07	0.03	0.05	0.15	0.35	0.3
Ortho-tolidine-Arsenite for Free Chlorine						
Maximum reading	0.30	0.70	1.8	3.5	10.0	20.0
Minimum reading	0.25	0.60	1.5	3.0	9.0	17.0
Average reading	0.29	0.64	1.65	3.4	9.3	17.9
Maximum variation	0.05	0.10	0.3	0.5	1.0	3.0
Ortho-tolidine-Arsenite for Total Chlorine						
Maximum reading	0.35	0.70	2.0	4.0	10.5	20.0
Minimum reading	0.30	0.60	1.7	3.5	9.5	17.0
Average reading	0.32	0.66	1.9	3.8	10.0	18.5
Maximum variation	0.05	0.10	0.3	0.5	1.0	3.0

containing more than 15 ppm. of free chlorine, smaller aliquots should be diluted to approximately 100 ml. with ammonia-free and chlorine-demand-free water.

Critical Points of Technique

For maximum accuracy in titrating free available chlorine residuals with ortho-tolidine it is essential that the analyst give careful attention to the following:

1. The ortho-tolidine solution must be of known standard strength. Solutions prepared from a good grade of ortho-tolidine or ortho-tolidine dihydrochloride in accordance with standard A.W.W.A. and A.P.H.A. procedure are satisfactory (6, 7).

2. Samples must be kept out of direct sunlight.

3. Samples should be acidified to below pH 1.8 just before the titration is started. One-third ml. of 1:1 hy-

drochloric acid per 100 ml. of the sample is sufficient for samples having alkalinities under 1,000 ppm.

4. When a light amber or orange color develops instantaneously (within 2 or 3 seconds) after the addition of 2 drops of ortho-tolidine to an acidified sample (333 ml.), free chlorine is present in excess of approximately 0.2 ppm. and the titration should proceed immediately. If only a light greenish yellow color develops instantaneously, the free chlorine residual is less than 0.2 ppm.

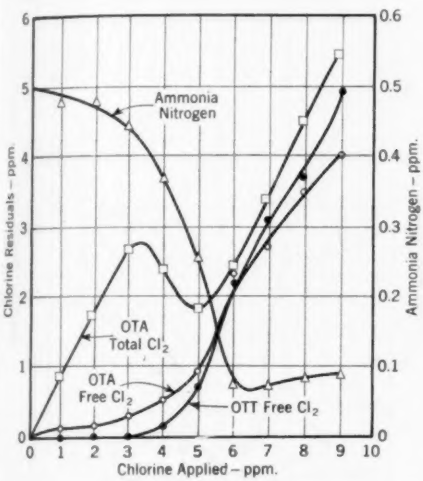


Fig. 1. Test After 5 Minutes at pH 7.0

If there is no instantaneous production of color by the first 2 drops of ortho-tolidine but a slow development of a greenish yellow color turning to a light amber or orange color within 1 to 3 minutes, there is no free chlorine residual in the sample, but chloramines are present.

5. Titration must proceed rapidly at the beginning in order to prevent secondary chlorine-consuming reactions between the small amount of ortho-tolidine and the large excess of chlorine. This caution is particularly significant for samples containing high residuals.

6. The total time for making a single titration should not exceed approximately 30 seconds. Chloramines will produce a sufficient amount of the red compound within approximately a minute to produce a slight orange color. Therefore if as much as one minute is required for a titration and chloramines are present, a slightly high reading for free chlorine will be obtained. The

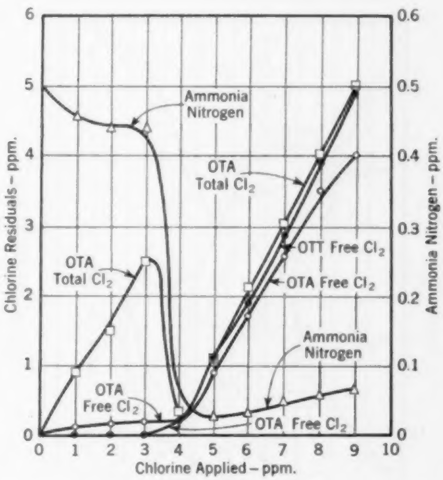


Fig. 2. Test After 1 Hour at pH 7.0

slow reappearance of an orange color after the end-point is reached results from the presence of chloramines.

7. A color comparison control for detecting the titration end-point is particularly advantageous for residuals above 1 ppm. It should be noted, however, that the end-point color for one residual level is not the same as at other levels. The end-point color, as well as the various colors during a titration, increases in depth with increase in free chlorine residual. Ac-

quaintance with these various color changes can readily be obtained through practice.

Field Testing Kit

With a simple "eyedropper" type of field kit, titrations can be made with sufficient accuracy for field tests for free residuals and even for plant control tests in the application of free residual chlorination.

Materials

Recommended materials for such a kit are:

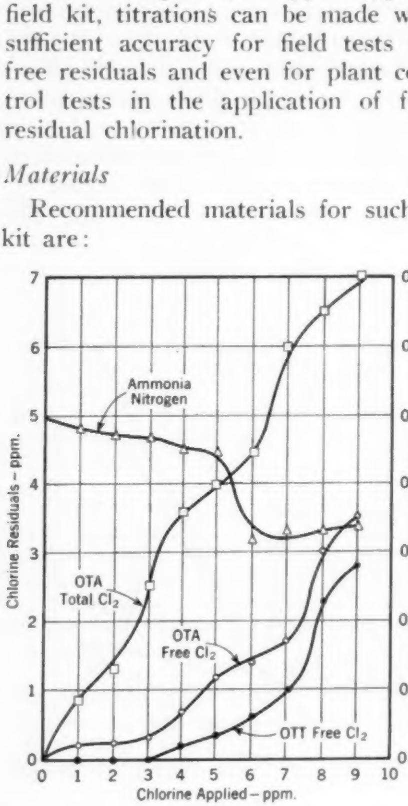


Fig. 3. Test After 5 Minutes at pH 5.5

1. Wide-mouth bottle of approximately 125-ml. capacity and with calibration marks at approximately 84 ml., 42 ml. and 21 ml.

2. A two-ounce prescription bottle of dilute (1 : 1) hydrochloric acid.

3. A two-ounce (amber) prescription bottle of standard ortho-tolidine solution.

4. Two eyedroppers, one of which is adjusted to deliver each milliliter of ortho-tolidine in 20 incremental drops.

Procedure

The procedure for using the kit is described below:

1. For residuals up to 3 ppm., use an 84-ml. sample and approximately 8 drops of dilute acid. Titrate with ortho-tolidine, using the calibrated eyedropper. Add the drops very rapidly until the maximum amber or red color is developed, then with moderate rapidity until the end-point is reached. Each drop of ortho-tolidine required represents 0.2 ppm. of chlorine.

2. For residuals in the range of 3 to 6 ppm., use a 42-ml. sample and 4 drops of acid. Each drop of ortho-tolidine equals 0.4 ppm. of chlorine.

3. For residuals in the range of 6 to 10 ppm. use a 21-ml. sample and 2 drops of acid. Each drop of ortho-tolidine equals 0.8 ppm. of chlorine.

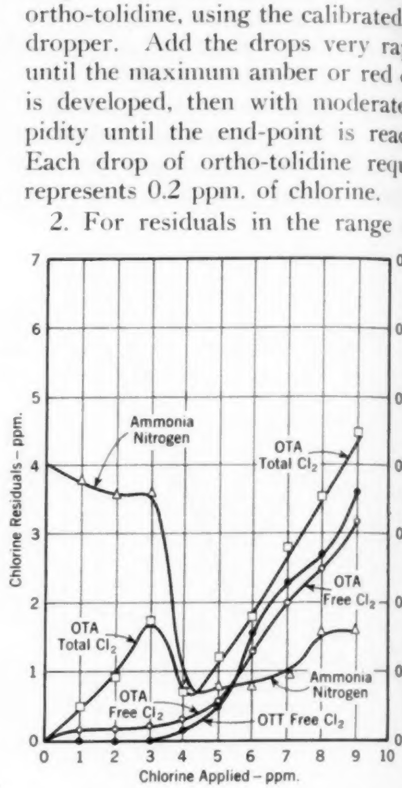


Fig. 4. Test After 1 Hour at pH 5.5

Lack of Interference

The presence of nitrite nitrogen, ferric iron or manganic manganese in water produces no interference with

the ortho-tolidine titration of free available chlorine residuals. In tests for this possible interference, as much as 25 ppm. of these oxidizing agents in acidified chlorine-free samples of water produced no red or amber coloration with ortho-tolidine but produced a considerable depth of the yellow ortho-tolidine color. Nitrite nitrogen, ferric

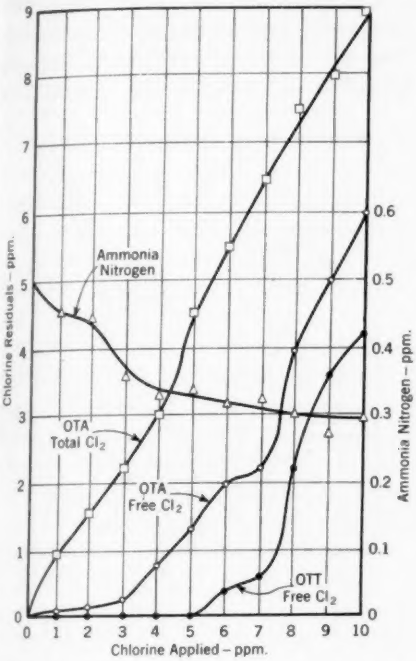


FIG. 5. Test After 5 Minutes at pH 10.0

iron and manganic manganese are sufficiently strong oxidizing agents to produce the yellow holoquinone of ortho-tolidine, but they are not sufficiently strong to produce the red chlorine-substituted holoquinone (8).

Precision and Comparison Tests

No Combined Chlorine in Samples

In Table 1 are presented results of precision and comparison tests of the ortho-tolidine titration procedure, the acid iodimetric method (7) for total chlorine and the ortho-tolidine-arsenite procedure (2) for free and total chlorine as applied to samples containing free chlorine but no combined chlorine. At least six determinations were made by each procedure on each sample under carefully controlled conditions of sampling, temperature and timing. The ortho-tolidine procedure gave satisfactorily reproducible results which checked closely with the results obtained by the other methods. The pre-

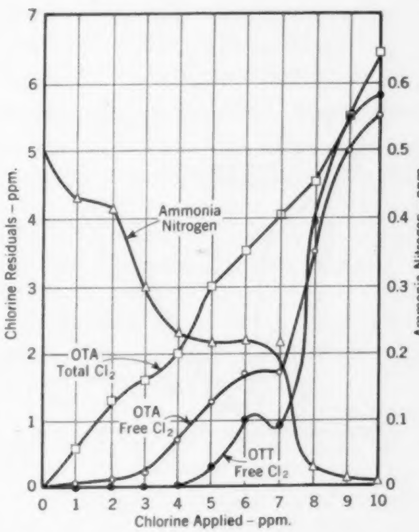


FIG. 6. Test After 1 Hour at pH 10.0

cision of the method was approximately the same as that of the iodimetric titration of total chlorine and better than that of the ortho-tolidine-arsenite colorimetric tests.

Free Residual Chlorination

Free residual chlorination tests were carried out at three different pH levels, 5.5, 7.0 and 10.0. Tap water from the Galveston, Tex.. city supply was used, which as drawn was at pH 7.8 and

contained approximately 300 ppm. alkalinity, 0.05–0.1 ppm. manganic manganese, 0.1–0.3 ppm. ferric iron, 0.1–0.2 free available chlorine residual and no ammonia nitrogen. Samples were cooled to below 15°C. and adjusted to the desired pH level; 0.5 ppm. ammonia nitrogen was added and the desired chlorine dosages applied. The temperature was maintained within the range of 15°–18°C. during the chlorine contact period. Ammonia determinations, ortho-tolidine titrations (OTT)

Additional laboratory experiments and actual application of the test in connection with free residual chlorination of many other types of water are needed before the full value and limitations of the ortho-tolidine titration procedure can be known. Comparison tests with the amperometric procedure (3, 4) for free and combined chlorine would demonstrate more adequately just what the accuracy of ortho-tolidine titrations is for measuring free available chlorine in the presence of

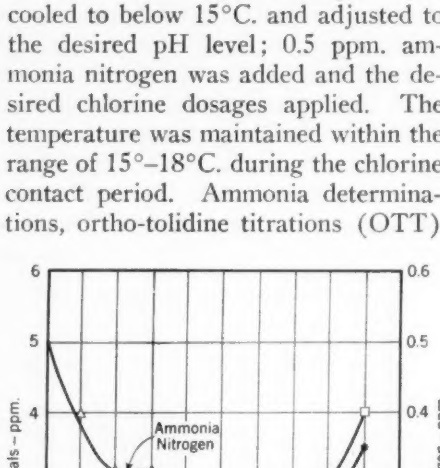


FIG. 7. Test After 2 Hours at pH 5.5

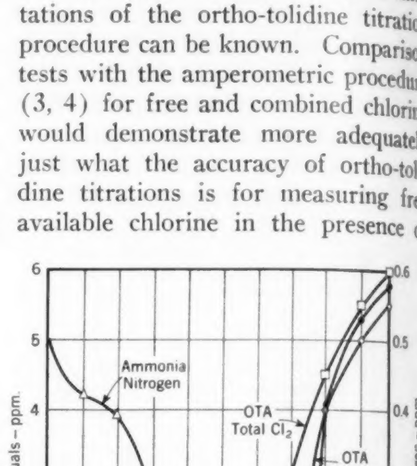


FIG. 8. Test After 2 Hours at pH 10.0

and ortho-tolidine-arsenite tests (OTA) for free and total chlorine were made after 5 minutes, 15 minutes, 1 hour and 2 hours of chlorine contact. The results of tests applied after 5 minutes, 1 hour and 2 hours are presented graphically in Fig. 1–8. The results of tests after 15 minutes were almost identical with those after 5 minutes; and, at pH 7.0, free residual chlorination was attained so rapidly that the chlorine and ammonia-nitrogen residuals were almost the same for the 1-hour and 2-hour periods.

combined available chlorine. The results obtained from the three series of free residual chlorination experiments, however, indicate that the test is fully as specific for free available chlorine as is the ortho-tolidine-arsenite test, and that it can be used quite reliably as a control test in the free residual chlorination of many types of water. The following considerations of the data presented in Fig. 1–8 do not give proof of the relative merits of the OTT and OTA tests, but they are of interest and indicate the desirability of further

experimental investigation along these lines:

1. At pH 7.0 (Fig. 1 and 2), at which the process of free residual chlorination progresses very rapidly (4, 9), and at pH 5.5 (Fig. 3, 4 and 7) at which it is appreciably slower, the OTT readings were zero until the chlorine to ammonia-nitrogen dosage ratio exceeded 6:1. The readings did not become appreciable until a free residual had been attained or the ratio of total chlorine residual to ammonia-nitrogen residual had exceeded 8:1. Moore, Megregian and Ruchhoft (4) have reported potentiometric and amperometric evidence that, at pH 7.0, little or no free chlorine is present in a chlorine-ammonia system until the chlorine to ammonia-nitrogen ratio exceeds approximately 8:1.

2. At pH 10.0, at which free residual chlorination progresses very slowly, the OTT readings were zero until the dosage ratio of chlorine to ammonia-nitrogen had exceeded 8:1 or the ratio of total residual chlorine to residual ammonia-nitrogen had exceeded approximately 10:1 (Fig. 5, 6 and 8).

3. For all tests in which pronounced breaks in the total residual curves were observed, the OTA readings for free chlorine were higher before and lower after the breaks occurred (Fig. 1, 2, 4 and 7). These differences were not significantly great, except perhaps for the higher dosages at pH 7.0. At these high chlorine residuals, the differences are barely within the limits of experimental error, but the trend of divergence is sufficiently consistent to indicate the merit of additional tests at higher chlorine dosages and longer contact times.

4. The OTA readings for free chlorine are appreciably higher than the OTT readings after 5 minutes for the chlorination tests at pH 5.5 and pH 10.0 (Fig. 3 and 5); this is also true at pH 10.0, after 1 hour, for all chlorine to ammonia-nitrogen ratios up to 14:1. This could possibly be due to the presence of a high proportion of nitrogen trichloride which may be sufficiently active to increase the OTA readings but not the OTT determinations. Marks and Glass (3) report evidence that production of nitrogen trichloride occurs during the free residual chlorination process and that its concentration increases with increasing chlorine dosage and decreases with time. The data presented in Fig. 3, 5 and 6 may support this evidence.

Recommended Practical Applications

The ortho-tolidine titration procedure for measuring free available chlorine residuals requires only the simplest of laboratory volumetric apparatus and reagents. It can be used reliably as follows:

1. It will serve as a satisfactory control test for free residual chlorination of many types of water.

2. True free residuals can be measured with a higher degree of precision than by the ordinary colorimetric tests.

3. A simple "eyedropper kit" adaptation of the procedure provides adequate accuracy for most field chlorination tests. Such a kit is particularly valuable for measuring high chlorine residuals used in such chlorination practices as disinfection of water mains, wells and reservoirs.

4. It can be used with a high degree of confidence with waters containing nitrites, iron or manganese.

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Discussion

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So far as this writer is aware, the titration method described has never been used in this manner before; it has been thought of, but never put into the form of a procedure. Clark, Cohen and Gibbs (1), in studying the meriquinones of ortho-tolidine, did add solutions of free available chlorine to solutions of ortho-tolidine to determine the potentials of the mixtures and the percentage of oxidation of the ortho-tolidine.

The author of this well-written paper must have anticipated most questions or doubts that may arise about the method, for they may all be resolved by a careful reading. The end-point of the titration is certainly difficult for the uninitiated to determine because the color change near the end-point is not great, nor is the end-point color the same for various chlorine residuals. In studying the end-point of the various residuals, one is confronted by a varying depth of yellow color that is quite different from the methyl orange alkalinity titration for various alkalinities. The author has given warning of these difficulties. This writer's first thought was to use a slightly overtitrated sample as a reference aid in obtaining the end-point; this possibility has been anticipated and suggested by the author. The author hides nothing. It is merely a matter of the uninitiated becoming initiated.

This writer does fail to understand, however, how the use of 1 ml. of 1:1 HCl ($6N$) per 333 ml. of the sample for pre-acidification depresses the pH to below 1.8 for samples with less than 1,000 ppm. of alkalinity. If a water had a methyl orange alkalinity of 1,000 ppm., 100 ml. of $\frac{N}{50}$ acid (or $\frac{1}{3}$ ml. of $6N$ HCl) would be required to depress the pH value to 4.0, and still more acid would be required to attain the required value of 1.8 or less. It has been noted (*2*) that 2 ml. of standard ortho-tolidine, containing 0.2 ml. of concentrated HCl or 0.4 ml. of 1:1 HCl ($6N$), will yield a pH of 1.7 in chlorinated water with no alkalinity, and a pH of about 2.45 with 1,000 ppm. of alkalinity.

This observation is not meant to imply that the amount of acid used is incorrect or insufficient, but that the resulting drop in pH may have been miscalculated. It is not being suggested that more acid be used for pre-acidification because when this titration is used for high residuals—apparently the best use for the procedure—the pH at the end-point is usually quite low because of the amount of acid that has been added with the ortho-tolidine.

The addition of some acid to the sample is doubtless required, but care should be taken not to add so much that the pH will be unduly depressed. The lower the pH value, the greater the possibility that some untitrated free available chlorine will react with other compounds—always a matter for concern when the pH value of a titration sample is altered. In colorimetric determination, the sample is added to an excess of the ortho-tolidine reagent, which acts as a reducing agent so that any free available chlorine reacts with it instantly before reacting with other compounds in the low pH water. In this titration method, it is possible for some free available chlorine to be consumed by the water before the titration is completed. Of course, the author's stipulation that the titration should be rapid is a partial answer to this objection.

The possibility of error due to loss of free available chlorine before the titration is completed should not be considered a detriment to the procedure. In the methyl orange titration procedure described by Taras (3), the sample is slightly acidified before titration, and many other such practices could be cited. Pre-acidification is also employed quite often with the iodometric method, when free available chlorine is known to be present.

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Author's Closure

The author is indebted to Mr. Chamberlin for observing the error in calculation and for his discussion of this and other points in the paper. One-third ml. of 1 : 1 hydrochloric acid is sufficient for the initial acidification of 100-ml. samples containing as much as approximately 500 ppm. of alkalinity. Approximately 1 ml. of acid should be used for samples having an alkalinity as high as 1,000 ppm.

Tuberculation Measurement as an Index of Corrosion and Corrosion Control

By Edwin W. Barbee

A paper presented on Oct. 24, 1946, at the California Section Meeting, San Francisco, Calif., by Edwin W. Barbee, Water Purif. Engr., Water Dept., San Francisco, Calif.

IN an attempt to measure the relative corrosiveness of San Francisco water and to determine the most efficient and practical corrective treatment, a series of studies have been made by the city water department. Except for the aeration of one source of supply, the only treatment applied to the water at the present time is disinfection. Natural storage and strict watershed sanitation, combined with chlorination, have provided an acceptable water.

The San Francisco supply is derived from three sources: the Hetch Hetchy project, the Alameda system and the Peninsula system. Consumption, which increased rapidly during the war years, now exceeds 100 mgd. The Hetch Hetchy supply has provided for these increases and now supplies more than half the consumer demand, although most of the water is mixed with local supplies before actual delivery to the consumers.

Table 1 shows typical analyses of the Hetch Hetchy supply and the Crystal Springs storage reservoir. The change in corrosive character is indicated by Langelier's saturation index, which has decreased from -0.2 to -0.9. Corrosion complaints and complaints of rusty water have increased. Future increases in the use of soft Hetch Hetchy water without anticorrosion treatment would further aggravate the problem. Treatment of this water now seems to be assured, however, and actual operations are expected to begin in about a year.

Preliminary Study

Prerequisites to the corrosion studies were a knowledge of the variables influencing the rate of corrosion and experimental apparatus that would give a quantitative expression of the results obtained. The corrective treatment, from a water works point of view, would be that necessary to preserve the flow coefficients and useful life of pipelines and other water supply appurtenances. The apparatus had to show the combined influences of the factors determining the amount and rate of corrosion; these variables include: (1) oxygen concentration, (2) by-products of corrosion, (3) hydrogen ion concentration, (4) alkalinity, (5) pipe material, (6) temperature and (7) film-forming salts and protective coatings.

Corrective treatment utilizing lime or phosphate offered the most promising results.

It was preferred that the quantitative results obtained correlate with established values in the literature and reflect field conditions. Such testing

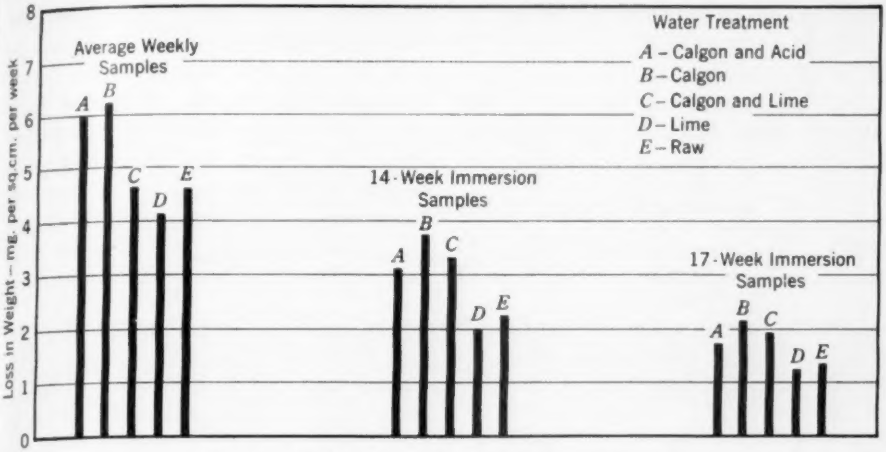

FIG. 1. Weight Loss of Corrosion Specimens

TABLE 1

Typical Mineral Analyses of San Francisco Waters

Source	Crystal Springs	Hetch Hetchy Reservoir	Crystal Springs	Hetch Hetchy Moccasin	Crystal Springs
Date Sampled	7/23/34	8/27/36	9/5/39	12/13/45	4/8/46
Conductivity	38.5	1.97	16.9	2.0	16.2
pH	7.6	6.4	7.7	7.1	7.7
Dissolved solids, *ppm.*	195.0	14.0	107.0	20.0	96.0
Silica and insolubles, *ppm.*	13.0	3.8	4.0	6.2	5.6
Sodium (Na), *ppm.*	19.0	0.0	7.6	1.0	8.6
Calcium (Ca), *ppm.*	39.0	1.1	17.5	2.7	14.9
Magnesium (Mg), *ppm.*	16.0	1.4	6.4	1.0	5.8
Iron (Fe), *ppm.*	0.02	0.025	0	0.02	0.01
Aluminum (Al), *ppm.*	3.0	0.56	0.6	0.07	0.4
Bicarbonate (HCO_3), *ppm.*	177.0	6.0	73.0	9.8	68.0
Sulfate (SO_4), *ppm.*	28.0	1.6	15.5	0.8	11.9
Chloride (Cl), *ppm.*	21.0	1.0	8.0	3.0	9.0
Hardness as $CaCO_3$, *ppm.*	163.0	11.0	74.0	17.0	61.0
Alkalinity, *ppm.*	145.0	5.0	60.0	8.0	56.0
pH_s	7.8	10.7	8.5	10.1	8.6
Saturation index ($pH - pH_s$)	−0.2	−4.3	−0.8	−3.0	−0.9

criteria include: (1) loss in weight and penetration, (2) decrease in dissolved oxygen, (3) reduction in cross-sectional area and (4) resistance to flow measurements. It was desirable that the testing equipment require a minimum of attention, be easily duplicated and allow for changes in treatment and control necessary for determining the effects of the variables influencing the rate of corrosion.

Previous work had been done by the department in 1941, utilizing loss in weight and mean penetration values. The results obtained could not be directly correlated with carrying capac-

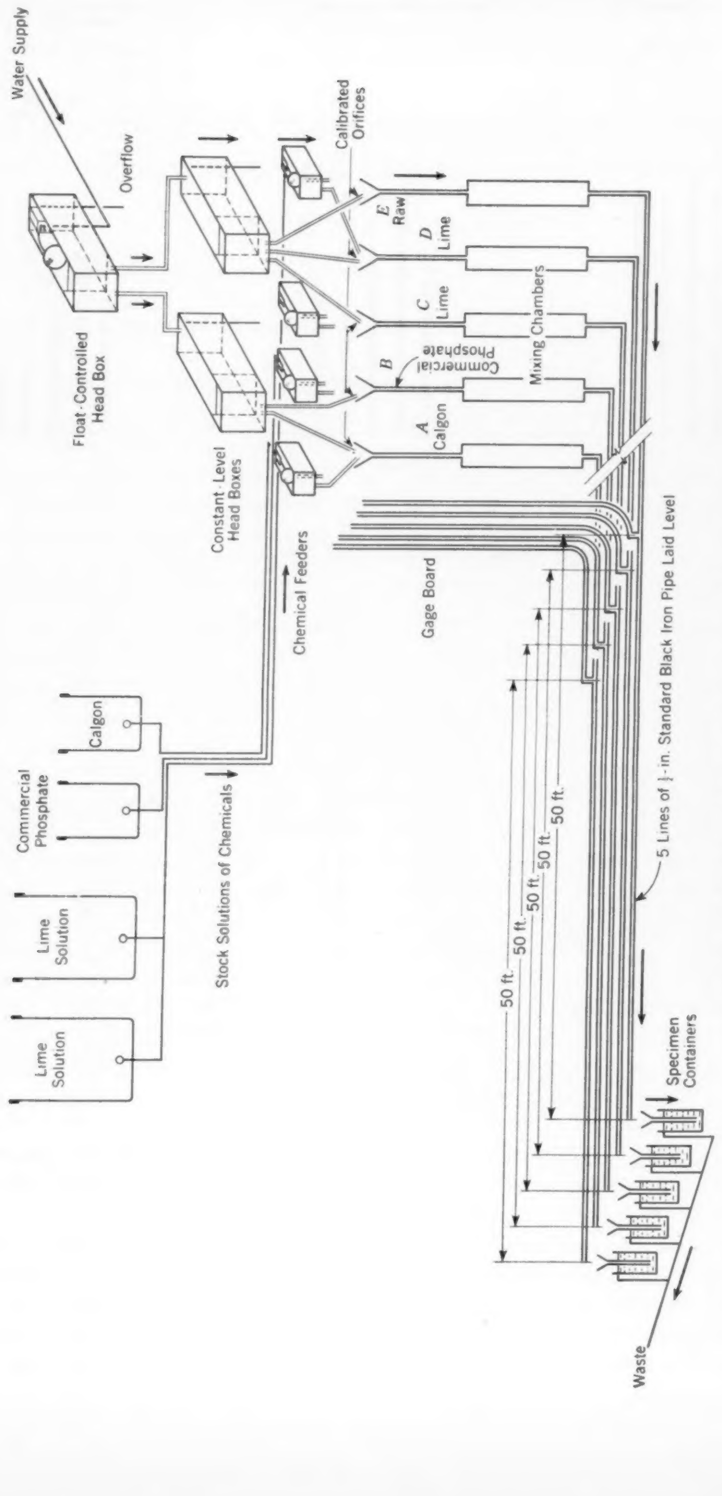

FIG. 2. Arrangement of Equipment for Corrosion Studies

ity, age or serviceability. Figure 1 shows the results obtained with one set of corrosion specimens. The unit used is loss in weight in milligrams per square centimeter per week. The average weekly bar graphs represent average values for specimens taken out, cleaned, weighed and re-immersed each week. The 14-week immersion graphs represent specimens submerged for 14 weeks, and the 17-week graphs show the loss in weight for a 17-week immersion period. A certain degree of protection was afforded by the rust coating of the specimens that were kept submerged, as shown by the higher rate of loss in the specimens cleaned and re-immersed each week. Loss in weight values varied in the *A* samples from 1.7 to 6.0 mg. per sq.cm. per week, depending upon the degree of protection afforded by the products of corrosion. On the other hand, the best treatment produced only 0.2 to 0.5 mg. per sq.cm. per week less loss of weight than the next most effective treatment.

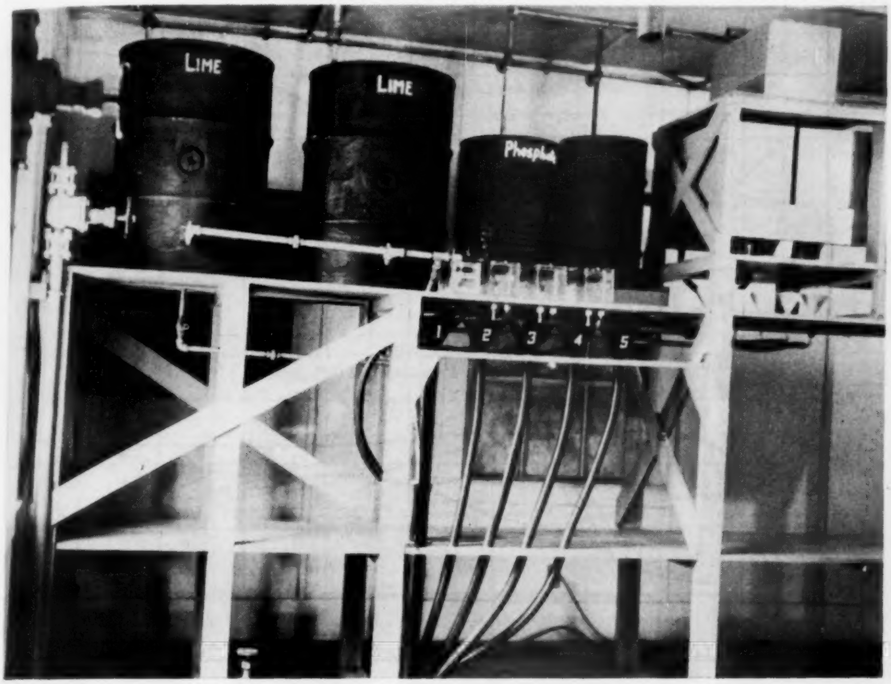

FIG. 3. Chemical Feeds and Constant-Head Boxes

Experimental Procedure

Figure 2 is a diagrammatic sketch of the corrosion test equipment utilized in the studies. Head loss is used as the index of resistance to flow, and the amount of tuberculation is reflected directly in the increased head necessary to pass the calibrated quantity of water. This arrangement, part of which is also shown in Fig. 3, should allow a determination of the effect of most of the variables affecting corrosion. Dissolved oxygen, pH, alkalinity and temperature determinations can

be made directly, and the pipe material, of course, is chosen. Film-forming characteristics of the easily controlled chemical feeds are reflected in the head losses, and the physical and chemical characteristics of the film can be determined by analysis and inspection on completion of the run. The flows can be calibrated and readily checked; their velocities are comparable to those encountered in practice. Loss in weight and mean penetration values can be determined from cut sections of the test run or from the suspended specimens. What decrease there is in dissolved oxygen can readily be determined. With the use of dye, the actual velocity can be found; this, with the calibrated flow, will give an effective cross-sectional area. The decrease in area can be correlated with loss of head, and the final results expressed in flow coefficients.

This study was initiated in 1941, discontinued in 1942 and resumed in 1946. The 1941 work was with Crystal Springs water and the 1946 studies with Hetch Hetchy and Crystal Springs water. The standard layout uses $\frac{1}{2}$-in. black iron pipe and a calibrated flow of 0.5 gpm. The 1941 experiments were made using $\frac{3}{8}$-in. pipe and 0.5 gpm. flows. The experiment is continuing.

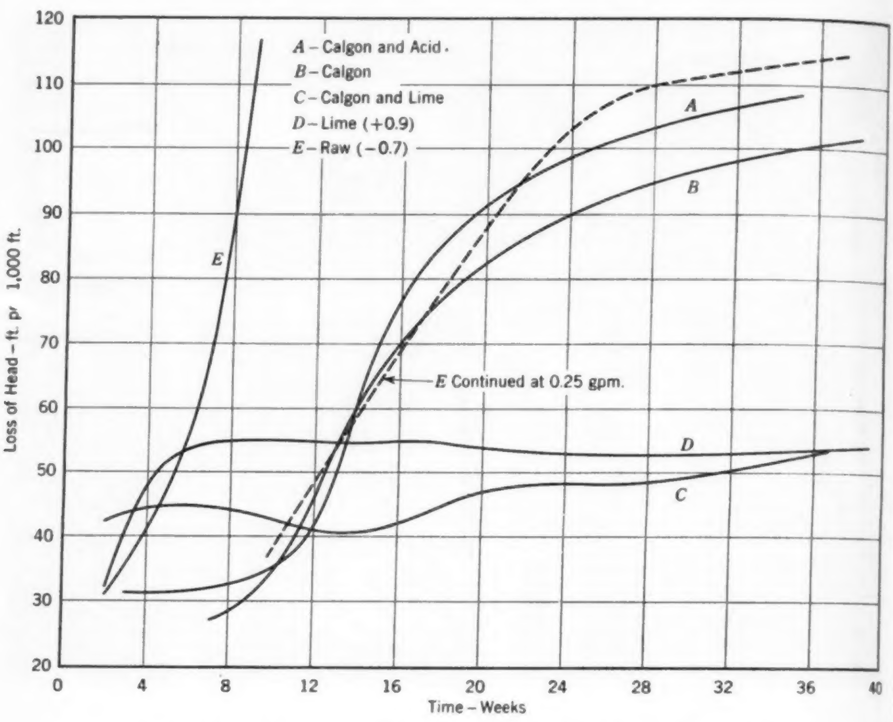

FIG. 4. Head Losses With Crystal Springs Water in $\frac{3}{8}$-in. Pipe

Curves Obtained

Head losses are plotted in Fig. 4 for the 1941 test with Crystal Springs water. Figure 5 shows the head losses for 1946 tests with Crystal Springs

water, and Fig. 6 gives the plotted curves showing head losses using Hetch Hetchy water in 1946. In all figures E represents the untreated raw water line; the other lines carry treated water. A dosage of 1 ppm. was used in all phosphate-treated lines. Where lime was used, the treatment was constant to give the saturation index noted in parentheses.

Using the head loss, flow and pipe data for each of the three sets of conditions, the flow coefficients (C) in the Williams-Hazen formula were computed. Figures 7, 8 and 9 show time plotted against coefficient C for each of the pipelines under the three sets of conditions. An attempt was made to correlate the per cent of C decrease in time with the saturation index for all lines using raw and lime-treated waters. These curves are shown in Fig. 10. In general, the relationship bears out Langelier's statement of "directional tendency and driving force" when applying the saturation index to specific pipe corrosion. It should be pointed out that the comparison made in Fig. 10 is for a short period of time, and final equilibrium has not been reached in the 1946 experiments.

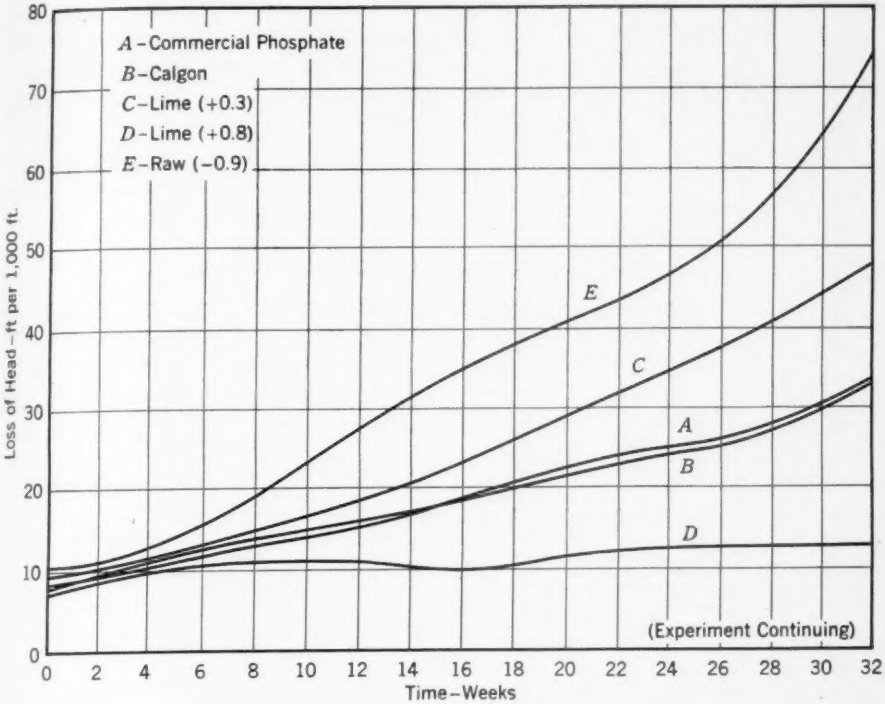

FIG. 5. Head Losses With Crystal Springs Water in ½-in. Pipe

Test Conditions

A discussion of the conditions under which these data were collected should place particular emphasis on those factors known to accelerate corrosion. Commercial standard black iron pipe was laid level, cleaned by concentrated sulfuric acid with an in-

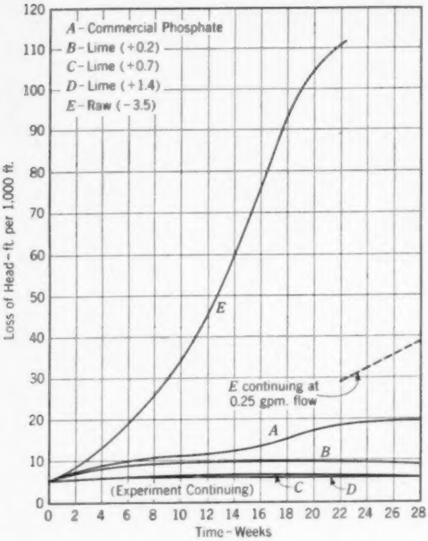

FIG. 6. Head Losses With Hetch Hetchy Water in ½-in. Pipe

hibitor and brushed. Care was taken to prevent galvanic action from seriously affecting the results by insulating the lines.

Dissolved Oxygen

Dissolved oxygen values were always near saturation in the incoming waters. Actual velocities in the pipes varied from 0.5 to 1.0 fps., according to the flows, size of pipe and amount of tuberculation. Alkalinity differences reflect the lime dosages which were fed as saturated lime solutions. Stock lime solution was open to the atmosphere for approximately seven days before the solution was freshly made. Commercial grades of sodium hexametaphosphate and sodium pyrophosphate (tetra anhydrous) were made up every three days.

Temperature

The average water temperature in the Hetch Hetchy lines was 59°F., with a range between 57 and 68°F. Temperatures varied between 58 and 69°F. on the early Crystal Springs experiment, with an average of 64°F. The Crystal Springs experiments of

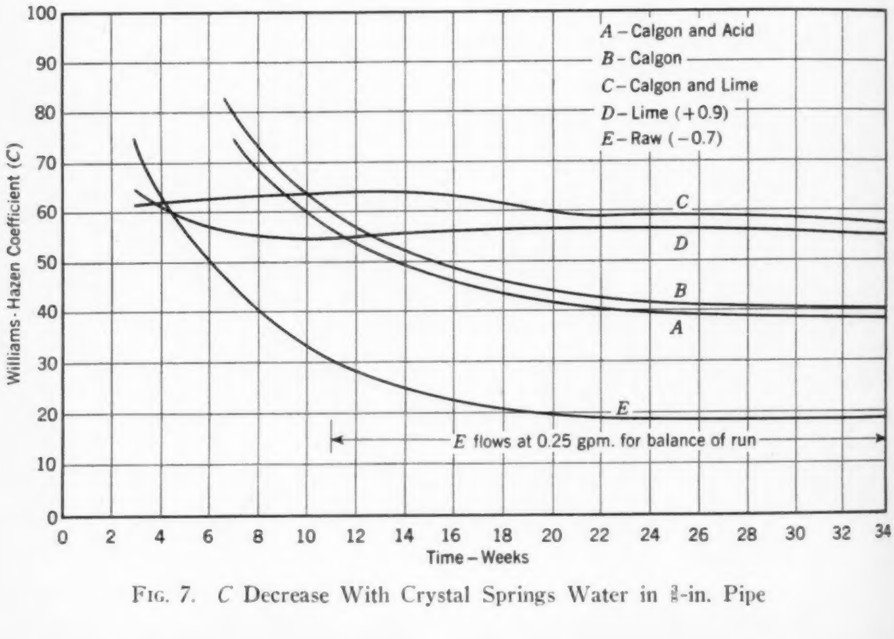

FIG. 7. *C* Decrease With Crystal Springs Water in ⅜-in. Pipe

1946 ran between 55 and 70°F., with an average of 66°F. The pH values of the raw and lime-treated waters ranged from 7.0 to 10.2, and the pH values of the phosphate-treated waters ranged from 6.1 to 9.0. Computed carbon dioxide values, using Tillman's formula:

$$\log CO_2 = 6.2874 - \text{pH} + \log HCO_3 \text{ (as } CaCO_3\text{)}$$

varied between 0.01 and 2.8 ppm. in the raw and lime-treated waters and between 1.5 and 39.0 ppm. in the phosphate-treated waters. Chemical feed rates for the various feeders varied from 3.8 to 19.4 ml. per minute. Lime and sulfuric acid were used to make pH adjustments. A dosage of 1 ppm. was used in all phosphate treatments.

Some interruptions occurred during the long runs, but all were minor and had little effect upon the results. The data obtained from the 1946 Crystal Springs test indicate a lower rate of corrosion in the early stages than was anticipated. This condition may be due to: (1) differences in pipe material, (2) inhibition of the metal by use of the acid cleaning material or (3) deposit or protective film due to cleaning or matter in the incoming water. Head losses with time as the experiment continues will indicate the

TABLE 2

Partial Data Summary—Average Values

Line	Loss in D.O. *ppm.*	pH	Alkalinity *ppm.* as $CaCO_3$	Temperature *° F.*	Ca *ppm.*
CRYSTAL SPRINGS WATER—MAY 14, 1941					
A*	0.3	6.1	25	64	19
B*	0.3	7.7	73	64	19
C†	0.4	9.0	86	64	27
D‡	0.3	9.1	84	64	28
E	0.4	7.7	73	64	19
CRYSTAL SPRINGS WATER—MAR. 19, 1946					
A*	0.4	7.6	57	66	18
B*	0.4	7.6	57	66	18
C‡	0.3	8.7	64	66	21
D‡	0.3	9.1	70	66	23
E	0.4	7.6	57	66	18
HETCH HETCHY WATER—APR. 22, 1946					
A*	0.4	7.1	10	59	4.0
B‡	0.2	9.5	18	59	7.0
C‡	0.1	9.8	26	59	10.0
D‡	0.1	10.2	36	59	15.0
E	0.5	7.0	10	59	4.0

* Lines receiving phosphate treatment (1 ppm.).
† Lines receiving phosphate and lime treatment.
‡ Lines receiving lime treatment.

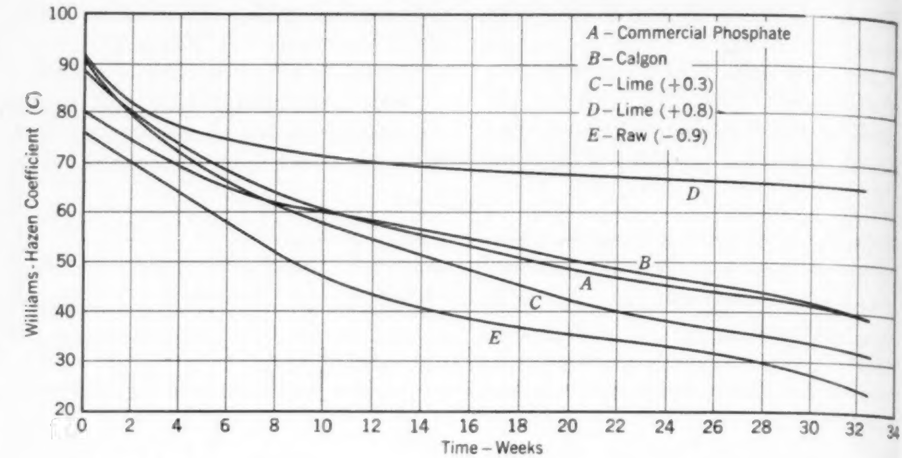

FIG. 8. *C* Decrease With Crystal Springs Water in ½-in. Pipe

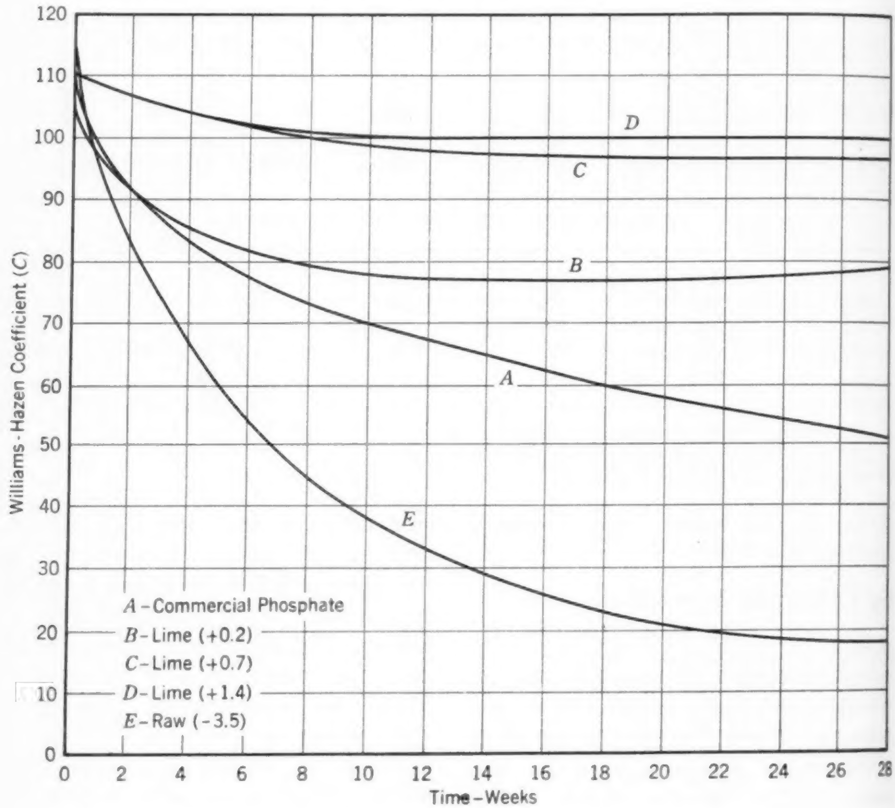

FIG. 9. *C* Decrease With Hetch Hetchy Water in ½-in. Pipe

nature of the variation. The time interval allowed for attainment of stability of the alkalinity relationship is small, varying between 20 seconds at the start of the run to 10 minutes when the head has built up and the mixing chambers are full. After this interval of mixing and reaction, the water enters the 50-ft. lines and flows through in 30 to 50 seconds, depending on the size of lines, amount of corrosion products and flow.

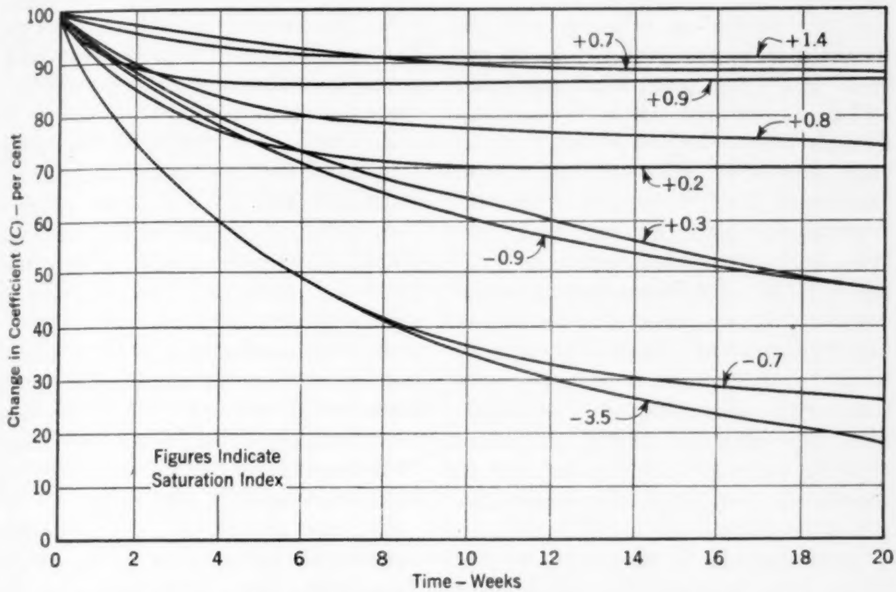

Fig. 10. Correlation of Saturation Index With Percentage of C Decrease

Microscopic Studies

The Crystal Springs water was chlorinated some distance before the experimental layout. No residual chlorine was detected in the raw water entering the corrosion lines. The Hetch Hetchy supply was taken from the raw water at Tesla Portal chlorination station before treatment. This supply had not been previously chlorinated. Microscopic examinations were made on material taken from the tanks, tubes and effluent containers in each of the experiments. In the Hetch Hetchy samples, a growth of the iron bacteria *Leptothrix* was identified in the storage tanks supplying the station. Growths of these bacteria occurred in the head boxes supplying the five lines. A thin matrix, containing diatoms, algae, organic and inorganic debris, and filamentous forms, was observed in the rubber connecting tubes. The lines were flushed several times and the residue examined. No active slime or filamentous growths could be observed.

Examinations of the Crystal Springs water in the corrosion apparatus revealed only organic and inorganic debris, algae, diatoms and protozoa. No active growths were observed in the tubes, boxes or containers. It cannot be stated definitely what effect organic growths had on the observed head losses; in these experiments, however,

it is considered negligible, compared to the chemical action of the water. The role of bacteria and organic growths offers a field for further experimental work. Dye tests were made on the Hetch Hetchy experiment after 22 weeks of service, and actual velocities through the lines were determined. These values, taken with those for the calibrated flow, were used to compute the effective pipe areas.

The decrease in effective area in line *A* was 10 per cent; in *B,* 14 per cent; *C,* 10 per cent; *D,* 5 per cent; and *E,* 25 per cent. It was noted that line *A,* which showed a reduction in area of only 10 per cent, had a head loss equal to 18 ft. per 1,000 ft., whereas *B,* with a reduction of 14 per cent, had a head loss equal to 9 ft. per 1,000 ft. This discrepancy may be explained by the physical character of the tuberculation. In the phosphate-treated lines, the rust deposits were continuous, flocculent and powder-like; the surfaces offered more resistance to flow than the deposits in the lime-treated lines, which were irregularly shaped and quite hard.

The amount of fixed residue obtained from two sets of samples, after flushing the lines, varied with the friction head loss. The decrease in dissolved oxygen values, as shown in the partial data summary of Table 2, was the highest in the raw water lines, averaging about 0.4 ppm. The phosphate-treated lines showed about 0.3 ppm. loss of dissolved oxygen. The decrease was lowest in the lime-treated waters. The more positive the saturation index number, the less the drop in dissolved oxygen.

Observations

On the basis of these data, the measurement of head losses directly reflects the aggressiveness or corrosive character of the raw and treated water. The following observations were made:

1. The decrease in the value of the flow coefficient (*C*) with time compares favorably with Langelier's saturation index.
2. The rate of tuberculation, using 1 ppm. of sodium hexametaphosphate at pH 6.1 and pH 7.7, is the same.
3. Sodium pyrophosphate and sodium hexametaphosphate in concentrations of 1 ppm. gave comparable protection as corrosion inhibitors.
4. Maintenance of a positive saturation index of + 0.7 would give a high degree of protection. The large scale treatment could doubtless be reduced in Hetch Hetchy and increased slightly in Crystal Springs water.
5. Lime treatment to a saturation index of + 1.4 in Hetch Hetchy water gave little added protection and would not be warranted on a large scale treatment basis.

Acknowledgment

The help of the members of the Purification Div. of the San Francisco Water Dept. is gratefully acknowledged.

Effect of Litigation on Water Appropriation in California

By Cornelius T. Waldo

A paper presented on Oct. 22, 1946, at the California Section Meeting, San Francisco, Calif., by Cornelius T. Waldo, Deputy City Attorney, Legal Div., Dept. of Water & Power, Los Angeles, Calif.

THE scope of this discussion can be restricted to a consideration of the effect on California water appropriation of the opinion in the Owens Lake case of *Natural Soda Products Co.* vs. *Los Angeles*, reported in 23 Calif. (2d) 193, and decided November 4, 1943. There has been a great deal of litigation affecting both Owens Lake and the water laws of California, but these cases are not of primary concern.

The *Natural Soda* case arises out of damages to mining operations of the company from flows of water into Owens Lake during 1937, which it is claimed the city could have prevented by diverting the water out of the watershed and either dumping it elsewhere or spreading it in the Owens Valley. It would be presumptuous for a lawyer to detail to engineers out of court the construction, operation or maintenance features of the Los Angeles aqueduct and water supply system, which are here involved.

Pertinent Litigation

It will be noted, however, that in 1912, another natural soda company and the Inyo Development Co. each brought suit to enjoin the diversion of water from the Owens River into the Los Angeles Aqueduct, upon the ground that such diversion would adversely affect the right to extract minerals from the waters of the lake (see *Los Angeles* vs. *Dehy*, 169 Calif. 234, and *Los Angeles* vs. *Superior Court*, 185 Calif. 405). The 1912 action is the exact converse of the recent *Natural Soda* case, in which compulsory diversion or disposal of water is sought in order to prevent its entry into Owens Lake—upon the same ground that mining operations would be adversely affected.

Other appellate decisions which may be noted are the *Inyo Chemical Co.* and *Southern Pacific Co.* cases against Los Angeles, arising out of damages from an aqueduct break at Ash Creek during a cloudburst in November 1926 (5 Calif. (2d) 525 and 545); the *Frost* case, brought to enjoin the use of aqueduct water on the claim that the water was unfit for human consumption (*Frost* vs. *Los Angeles*, 181 Calif. 22); the *Hillside Water Co.* case, brought in 1931 to enjoin the city from pumping the Bishop-Big Pine ground water basin (*Hillside Water Co.* vs. *Los Angeles*, 10 Calif. (2d) 677); the *Los Angeles-Inyo Farms Co.* case brought in 1930 to enjoin the operation of city pumps in Owens Valley, a case which was converted into an eminent domain proceeding (*Los Angeles* vs. *Los Angeles-Inyo Farms Co.*, 134 Calif. App. 268);

the *Mono Power Co.* case brought in 1920, wherein the city was denied the right to condemn a portion of the lands and water rights needed for power development below Long Valley on the Owens River (*Mono Power Co.* vs. *Los Angeles,* 284 Fed. 784 and Note 33 Calif. App. 675); cases involving land titles and taxation matters in Mono County (*Los Angeles* vs. *Board of Supervisors,* 105 Calif. App. 199, 108 Calif. App. 655); the *Silver Lake Power and Irrigation Co.* case, involving appropriations by the city and the company on Rock Creek and the effect on initiated rights of withdrawals of public land from entry (*Silver Lake etc. Co.* vs. *Los Angeles,* 176 Calif. 96); the *Watterson* case, brought in 1927, involving the affairs of the Owens Valley Irrigation Dist. (*Los Angeles* vs. *Watterson,* 8 Calif. App. (2d) 331); the *Aitken* case, decided in 1935, in which was involved the right of the city to condemn littoral rights on Mono Lake in the Mono extension of the aqueduct (*Los Angeles* vs. *Aitken,* 10 Calif. App. (2d) 460); and the *Glendale-Burbank* cases, decided in 1943, particularly involving the pueblo right of Los Angeles, but covering the aqueduct and other supplies relied upon by the city in the San Fernando Valley (*Los Angeles* vs. *Glendale,* 23 Calif. (2d) 68). This is not a complete list of appellate litigation revolving about the Los Angeles Aqueduct and affecting Owens Lake, but the enumeration gives some idea of the complexities of the problem and offers a field for study of the vagaries of judicial imagination or the lack of it.

The reason for discussing what may appear to be purely local litigation at such length is the principle it establishes. The 1943 *Natural Soda* decision may only be applied against the city of Los Angeles, but possible application of the holdings of the case against other water appropriators should be carefully considered by each of them.

Appropriation of Water

All appropriations from surface bodies of water or underground streams flowing through definite, known channels have been under the exclusive control of the Water Commission Act since 1914, its effective date. The act is now incorporated in the Water Code. There is no statutory provision for appropriation from other ground water sources, and these appropriations are regulated, if at all, by case law, except for a misdemeanor provision for waste from artesian wells. All water rights come within the effect of Article XIV, Section 3 of the California Constitution, adopted in 1928, which limits rights to the beneficial use to be served. The constitutional amendment resulted from the *Herminghaus* case (*Herminghaus* vs. *Southern California Edison Co.,* 200 Calif. 81), in which lower riparian owners on the San Joaquin River extracted damages from the power company without any showing of injury to the riparian rights. Formerly, in disputes with an appropriator, a riparian owner was entitled to the full flow of the stream. The only methods available to defeat lower riparian interests were by adverse possession or condemnation.

Prior to passage of the Water Commission Act, appropriative rights were prosecuted by actually taking water and devoting it to beneficial use, or by filing under the Civil Code and diligently applying the water to beneficial use. These rights were per-

fected against lower riparian owners by adverse use.

The water rights of Los Angeles in Owens Valley and in Mono are based upon practically all breeds of claim, except the pueblo right, and embrace surface and ground water sources. Prior to the 1943 *Natural Soda* decision, it was always assumed by the city that its use of water rights was for beneficial purposes, and that taking water from its source for the purpose of wasting it elsewhere was subject to being enjoined.

It has been claimed that the Owens Valley and the Los Angeles Aqueduct present a rare situation not to be found elsewhere. This claim is easily met, when other large diversions of water in California and elsewhere are considered. The appropriations of the Kings River and the consequent effect of the possible failure of these appropriations to use the entire flow of the river would and did result, in 1938, in large flows into Tulare Lake. The same situation exists between the Kern River appropriators and Buena Vista Lake. The Clear Lake Water Co., an appropriator from Clear Lake in Lake County, has the interesting problems of having to enjoy its water right in a manner that will protect littoral owners on that lake and riparian owners on Cache Creek, the outlet of the lake. Caught between one injunction to avoid injury held by the lake landowners and another injunction held by the creek landowners, the company is powerless to act.

Owens Lake Case

Conditions similar to those at Owens Lake exist on all of the saucer lakes in the state that are fed by tributary streams in which substantial water rights exist. Nor is it necessary that a lake be involved for similar situations to arise. Any major storage project can provide the basis for application of the case law of the 1943 *Natural Soda* decision. This case law, in its bearing upon water appropriation, may be summarized as holding that:

1. A lower proprietor on a stream has a right to rely upon a long-continued diversion by an upstream appropriator of water, and the upstream appropriator may not alter the regimen of his taking to the injury of the downstream proprietor.

2. The upstream appropriator has a duty to dispose of surplus water, for which he has no beneficial use, utilizing the capacity of his diversion and storage works in such a manner as to cause no injury to the downstream proprietor.

It is believed that the first point is fairly sound, provided that the court comprehends the facts, and variations reasonably necessary for operation, maintenance and beneficial use are not prohibited. There does not seem to have been comprehension of the facts in the 1943 *Natural Soda* Supreme Court decision, as may readily be gathered from a reading of the District Court of Appeal opinion in the same matter (reported in 132 Pac. (2d) 553), in which the trial court record was given a more thorough review. There was no variation from prior conduct by the city in 1937; in fact the city diverted more water than in previous years. The Supreme Court takes no notice of the long cycle of dry years from 1919 to 1936, or of the natural fact—of which both the court and the mining company should have been aware—that a wet cycle was inevitable. The operations of the city during the long dry cycle could not form any

basis for prognosticating wet-cycle activities upon which the lower proprietor could rely.

It is the second point which is legally unsound and likely to cause great difficulty to all upstream appropriators. In effect, the court requires all appropriators to employ whatever excess capacity they have in their supply systems for flood control, in order to prevent injury to downstream appropriators. Such a duty was, prior to this decision, regarded as a function of such agencies as flood control districts, the states or the federal government.

In addition to the basic error in law, the court failed to consider what must occur if the city diverts surplus water not needed for its own beneficial use, and dumps it out of the watershed. The court suggested the Santa Clara River or the Mojave Desert for dumping grounds. During the long dry cycle, just preceding 1937, the city had no occasion to dump water and acquired no rights to such an activity. Dumping of water during periods of high flows would probably coincide with an overabundance of water in the areas where the dumping occurs, at least during such state-wide storms as occurred in 1938.

Along the Santa Clara River there is a highly developed farm and urban area. Any injury to this area resulting from the release of water would subject the city to lawsuits far more serious than those arising in the Owens Lake area. The justices of the Supreme Court and persons having some interest in the geography and geology of California have no doubt at some time seen or heard of the mines operating in the Mojave Desert. A little consideration of the matter should make it apparent that the dumping of any considerable amount of water by the city in the Santa Clara River, the Mojave Desert or elsewhere, would merely substitute new plaintiffs for the Natural Soda Co., and plaintiffs with a much better case.

The decision in the 1943 *Natural Soda* case placing flood control duties on a water appropriator, without regard to his needs for beneficial use, should be carefully examined by all water works operators, and a concerted effort should be made to obtain a correction of this judicial error. The right to appropriate water for beneficial use should not be saddled with the duty to operate the excess capacity of water works to dump water out of the watershed of origin, or to waste water in any manner.

Repairing a Surface Wash System

By Herbert C. Schmitt

A paper presented on Nov. 16, 1946, at the Wisconsin Section Meeting, Green Bay, Wis., by Herbert C. Schmitt, Asst. Supt. of Filtration, Water Purification Plant, Milwaukee, Wis.

UNTIL recently, the Milwaukee, Wis., filter plant used the orifice type of wash water system, in which the expansion of the filter sand during backwashing raises the sand level 50 per cent, from about 2 in. below to 9 in. above the wash pipes. The $\frac{1}{8}$-in. orifices in the pipe are 8 in. apart and are staggered in alternate pipes, which are $21\frac{3}{8}$ in. apart. Dresser couplings are used and galvanized angles support the pipes.

The surface wash system has been in service since the Water Purification Plant was placed in operation in 1939. Every fall, when pumpage drops off, all 32 filters are drained and thoroughly scrubbed, all foreign matter is removed from the sand, and each filter thoroughly inspected. Except for clogging of the laterals with sand, which is composed of 22 in. of hard, durable, rounded grains between 45 and 50 mm. in size, the system operated satisfactorily for four years. After the sand had been removed, further clogging was prevented by changing the washing procedure to maintain pressure on the orifices sufficient to keep out the filter sand. Before this washing procedure was adopted, it was necessary every two or three months to poke the sand out of the laterals. A few holes had been enlarged, due to entrance of the sand.

Erosion Discovered

In the fall of 1941, after two years of operation, slight discolorations about the size of a dime were noticed in the galvanizing around the orifices. Two years later, it was found that the discolored areas had started to erode. This erosion occurred around 25 per cent of the orifices, and was well distributed throughout all filters. At this time it was also found that the metal around the outside of a very small number of the orifices was gouged out. This indentation was similar in appearance to a hole such as is made by an irregularly shaped countersink with a flat side.

In the spring of 1944, after four and one-half years of operation, observers were surprised to find that the metal around quite a number of the orifices had been gouged out in several of the filters that had been taken out of service for valve repairs. The size of the holes had not enlarged. That fall, holes were observed in from 20 to 50 per cent of the orifices in all the filters. The depth of gouging varied considerably. It was then realized that the holes were due to something other than the breaking down of the galvanizing or flaws in the pipe, as had at first been thought. The survey showed that there was no particular

pattern. This condition existed in all the filters and in all sections of the filters.

It was definitely decided at that time that a use factor together with a corrosion factor had contributed at first to wear through the galvanizing, and then to start the scouring or countersinking action which finally cut through the pipe. It could be expected that eventually all the holes would be scoured out and enlarged. The problem was not one that could be solved by fixing or touching up only the holes which had started to deteriorate.

The rapidity of the enlargement of the countersinking, once it had started, was surprising, but it was thought that there would be time to divide the repair work into quarters, and finish a quarter each year. While the water works engineers were investigating and planning, one of the filters that had been checked during the fall of 1944 was rechecked after an additional three months of service. The engineers were surprised and alarmed to find that frequently the action had carried completely through the pipe, irregularly enlarging many of the holes. The action had been accelerated beyond belief during the three-month period.

In the final stages, it appeared that the countersinking did not go through in a straight angular line, but leveled out, leaving the inner wall a thin shell of paper thickness, in which the size of the original hole was scarcely changed. One could break through this thin shell and enlarge the hole with any blunt instrument by hand. In fact, it was possible to push an ordinary wooden pencil through a $\frac{1}{8}$-in. diameter hole until the hole was the full size of the pencil. In this filter, which was one of the worst, 30 per cent of the holes were still the same size as when originally built, and the galvanizing had only partly worn off, but the effectiveness of the surface wash system started to drop off, due to loss in pressure as a result of the enlargement of the holes. It was now only a matter of time before all filters would be similarly affected. Two months later, an inspection showed that all filters were working inefficiently. Many of the holes had increased to a diameter of $\frac{1}{4}$ in. and were getting larger at a very rapid rate.

Inquiry at Racine, Wis., showed that the same sort of action had been experienced. The Racine filters are equipped with a vertical type of piping at the ends of which are perforated caps. These caps had to be replaced at intervals of from two to four years. Replacing the caps is a much simpler problem than replacing the pipes, of which there are 64 in each of the 32 filters at Milwaukee. Each pipe has approximately 55 orifices.

Planning Repairs

The following methods of repair were considered:

1. Replacing the pipe.
2. Filling existing orifices either with new plugs, or by welding or brazing and drilling new holes.
3. Installing new inserts of the screw type in the existing holes.

The installation of new inserts appeared to be the best solution. As the diameters of the holes were increasing rapidly, the surface wash system was taken out of service to prevent their enlargement to a point where the installation of inserts or brazing would not have been practical.

Experiments were then conducted to determine the type of insert to in-

stall. One suggestion was a clinch type of button insert put into a $\frac{1}{4}$-in. hole, which could be expanded and set snugly in the hole to get away from possible electrolysis or corrosion that usually manifests itself on the threads of galvanized pipe. These inserts were to be made of babbitt so that they would conform with the curve of the outside of the pipe, and a $\frac{1}{8}$-in. hole was to be drilled through the center of the button. The diameter of the button was approximately $\frac{1}{2}$ in. on a plane at right angles to the center line of the surface wash holes.

At the same time the author was carrying on experiments with some brass nozzles which could be threaded into the pipe, and made these nozzles of three or four shapes and sizes. Several special pipes were made with these inserts and it was attempted to use them in the surface wash system so that they could get actual service. The use factor and the economics of this procedure, however, did not afford enough time to carry out the experiment to its proper conclusion through the ordinary way of washing filters. A special vat had to be contrived, therefore, in which to make the experiments.

Experimenting With Plugs

To build a vat similar to a rectangular filter would itself be a time-consuming task, however, and time was badly needed to begin the repair job. An ordinary 50-gal. galvanized garbage container was therefore filled with water and the sample pipe immersed. With the buttons in water only, the pipe was connected to the wash water line for the proper pressure. This experiment was run for two weeks, after which there was no deterioration of the babbitt button holes. The galvanized container was then half-filled with sand and the pipe placed so that one button was in the sand and two in clear water. It was known that the agitation in the galvanized container would not be the same as in the filter, but it was hoped that similar conditions of orifice corrosion and erosion would result. In 24 hours there was a distinct shine on the surface of the babbitt button, although the wear could not be measured. In three days the wear could be measured, but was in the thousandths of an inch. After a week of this continuous running, the same gouging and countersinking that had occurred in the surface wash system piping took place on the babbitt button. The action of scouring was now very positive and effective in enlarging the indentation (Fig. 1). The test was then discontinued, for it was known that the babbitt button was not the solution.

Tests of Nozzles

Another section of pipe was connected, using the various brass nozzles for the experiment. Although not run to completion, all nozzles showed much better wearing ability than the button type. In fact, there was no wear at all at the base of the nozzles, and the paint or grease that was put on the base of the nozzles remained intact, showing that the use of nozzles had prevented the scouring which was so evident on the orifice type. The nozzles, however, did show wear at the tips, which were of various diameters. It appeared that the wider the tip of the nozzle, the more the wear, although there were not enough shapes to give a definite indication.

While considering other sizes and shapes of nozzles to be made of brass, it was decided to try a fitting manufac-

tured by the Alemite Co. of the shape with which the author intended to experiment. All that was necessary was to take the ball out of the fitting and enlarge the hole to the required $\frac{1}{8}$ in. Although the fittings were not quite the shape desired, three of them were tried, and experimenting for a week showed that they were hard enough not to show excessive wear.

An experiment was then planned to give a use factor similar to 20 years of operation, using the Alemite fit-

FIG. 1. Failure of a Test Fitting

tings on one side of the test pipe and the babbitt buttons on the other side. After a test run equivalent to six years of operation in the surface wash system, the button was completely gouged out in the same way that the surface wash pipes had been, and the hole enlarged into the galvanized pipe itself to such an extent that one could thrust one's little finger into it. The progression of the slow action at the start to the rapid failing at the finish was similar to or identical with what had happened in the surface wash system.

On the experiment with the nozzle conducted on the opposite side of the pipe, no deterioration could be measured. Even after 20 years' use had been approximated, it was not possible to measure any wear, although the action of the sand was beginning to shine the tips of the nozzles. The paint at the base was not worn away or even marred, showing that there was no abrasive action at the base.

Several other tests, using ordinary plugs through which holes were drilled, were made, but it had already been decided to use either brass nozzles of one of the shapes that had been tried or the Alemite nozzle with the proper size hole, whichever could be delivered most quickly and economically.

Cost Considerations

Estimates for the fabrication of 120,000 brass nozzles were solicited, but with very little response. Shops equipped to manufacture the nozzles in large quantities would not bid, and the only definite information obtained was that the price per nozzle would range from 5¢ to 10¢ each. A quotation was received, however, with a promise of two months' delivery, from the Alemite Co. The price quoted was 3.2¢ each for their regular fitting No. 307998 without a lock ball and with the proper $\frac{1}{8}$-in. hole. This fitting was to be made of the same material and hardened in the same way as the regular fitting.

There are 55 orifices in each lateral, making 3,520 to a filter, or a grand total of 112,640 orifices in the plant. The cost per lateral for the inserts would therefore be 55 × 3.2¢, or \$1.76. The price of replacing each of the 64 surface wash pipes in a filter was esti-

mated at not less than \$3.70 per 18.5-ft. lateral, at the very conservative cost of 20¢ per ft. for 1¼ in. galvanized pipe. There would be an additional cost for drilling the holes and bending the pipe. The experiments had shown that a life of approximately 20 years could be expected for the inserts, compared to the previous experience of five years if the holes were welded or brazed and new holes drilled. The labor cost of plugging the holes and drilling new ones would be more than that of drilling, tapping and installing new inserts. It was therefore decided to purchase the Alemite fittings.

Establishing Repair Technique

While delivery of the 120,000 Alemite fittings was pending, enough fittings were obtained for three-quarters of one filter and regular plugs were found for the other quarter. By drilling these fittings by hand and rehardening them, and also by drilling ⅛-in. holes in the plugs and casehardening with potassium cyanide, enough fittings were obtained to develop the procedure for full-scale drilling and tapping of the 32 filters. A hole shooter and a drill press were borrowed from other city departments.

Angle of Drilling

The surface wash system design required that all jets of water discharge at a plane parallel to the level, horizontal surface of the sand when the filters were drained. This required that the holes be drilled on each side of the pipe at an angle of 180 deg., and in a perfect line or plane. When the original installation took place, it was found that, although the pipes were drilled with the lines of holes exactly at 180-deg. angles, some pipes were twisted so that the jets on one side would shoot water into the air and, on the other side, obliquely into the sand. It was found that some 50 pipes had to be taken out, given a heat treatment and twisted, then rechecked, taken out again and galvanized. Some that were not too far out of line were twisted cold, so that the jets of all the pipes were more or less in a horizontal plane, although not perfectly so. Because of this experience, the author had the machinists arrange a device on rails which would drill the holes vertically and at right angles to the short vertical section in each pipe.

There are a number of bends in the pipe which are below the vertical section, and which give the proper clearance of the wash water troughs together with the proper uniform spacing of pipes. Hence, not all vertical pipes have a straight right angle bend, which could be easily handled. The machinists, after taking measurements, did not believe it was possible to get the correct angle and perfect plane by the use of the short vertical section which was to be run on the rail, and were reluctant about building a permanent structure until they had checked the principle.

The author therefore allowed them to make a crude bench to attach the rail, take out several straight pipes and drill those with a holeshooter he had borrowed from another department, thread the pipes by hand and replace them for trial. Even the simple operation of taking a few pipes out of the filters caused trouble which was thought quite serious for fast operation. Three rubber gaskets were ruined in the couplings, and one of the couplings was badly stripped. In the hope that this percentage of trouble would not prove typical, 100 rubber gaskets and three complete couplings

were ordered for replacements. It was later found that the trouble was caused by not knowing how to handle the pipe, as not more than six of the gaskets and none of the complete new couplings were needed.

In enlarging the holes of these few pipes, the machinists fortunately ran into some of the worst trouble at an early stage, discovering that there was not enough material left in the pipe to put in a standard $\frac{1}{4}$-in. thread. The next larger size hole was drilled and bushings were used around the Alemite fittings to make them fit. A few special plugs had to be made to act as bushings.

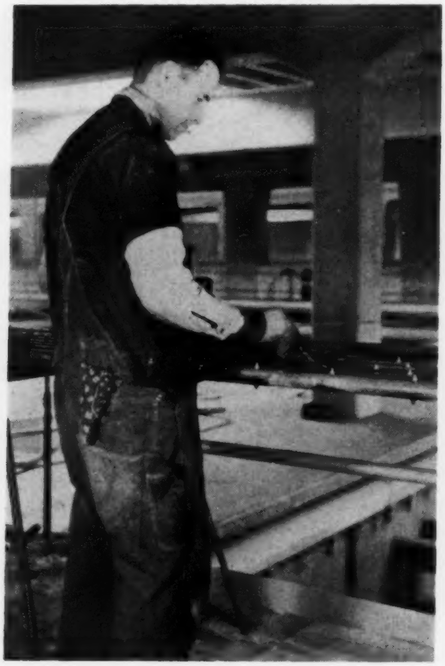

FIG. 2. Painting Pipe and Fittings

Grease and Paint Trials

As these pipes were the "trial horses," several kinds of grease were tried on the threads before screwing in the fittings, and a "Lubriplate No. 130–AAA" grease was decided upon for the main project. Several kinds of paint were also tested, in order to protect the fitting threads as much as possible, and the Wailes Dove-Hermiston Corp.'s "Bitumastic No. 50" coating was applied over a dry coat of their "No. 70" primer (Fig. 2). The pipes so repaired were reset in their original positions and the surface wash checked. It was found that the jets from the Alemite fittings were perfectly aligned, and that each jet hit the adjacent pipe squarely in the center (Fig. 3).

FIG. 3. Checking Installed Pipe

There still remained for testing the pipes that were bent to get underneath the wash troughs. One of each of the three different kinds of bends in each

filter was removed, and it was decided that rolling the short vertical section of pipe on different elevations of rail would give the proper angle for the plane of water to be in conformity with the rest of the pipe. Although one bend was actually drilled, all were satisfied that with a tilting table all the pipes from one filter assembly could be completed, reinstalled and each filter put back into service successively.

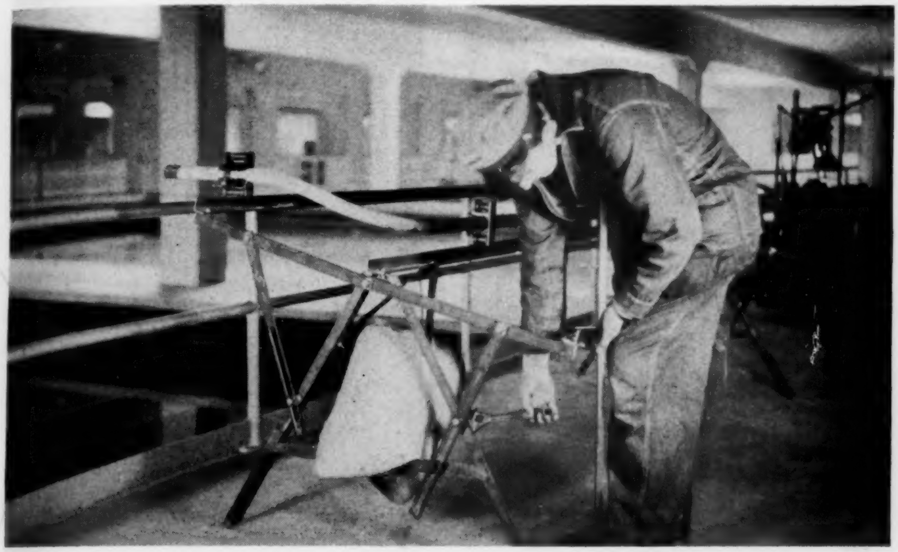

Fig. 4. Setting the Table Guides for Bent Wash Pipe

Production Plans

A machinist was given the problem of setting up tilting tables for a large holeshooter and for a tapper so that the final production method could be tried on the uncompleted filter. He developed the arrangement, shown in Fig. 4 and 5, which allowed a continuous flow of pipes to be drilled and tapped, have nozzles inserted, and be greased, painted and carried back to the filters.

The intention was to use enough manpower so that one filter could be taken out of service and one put back in service every three days. Reconditioning the first filter with hand-drilled Alemite fittings and hand-drilled plugs provided an opportunity to check every operation, so that the goal of one filter to be completed in three days could be attained, if not bettered.

During the three months that the surface wash system was not in use, mudballs, cracks, and irregularities began to develop in the filter surfaces. For the first time since the plant was put into operation, the clear well was slightly cloudy. The maximum turbidity, however, did not exceed 0.1 ppm. at any time. Although the condition was not serious, it was unusual, and became worse as time elapsed.

Making the Repairs

It was indeed a relief when the information arrived that the Alemite fittings would be delivered in 30 days.

The surface wash piping was then removed from a few filters; new holes were tapped (Fig. 6), bushed and threaded; and the pipes were stacked in various locations until the fittings were delivered. This provided an opportunity to prepare for the work ahead, although it necessitated leaving eight filters out of service.

Figure 7 shows the completed pipes ready for installation.

It is by no means expected that there will be no more filter maintenance work, but the nozzles are expected to last 20 years. It is anticipated, however, that a watch will have to be kept on the pipe and nozzle threads, and that the paint sealing the

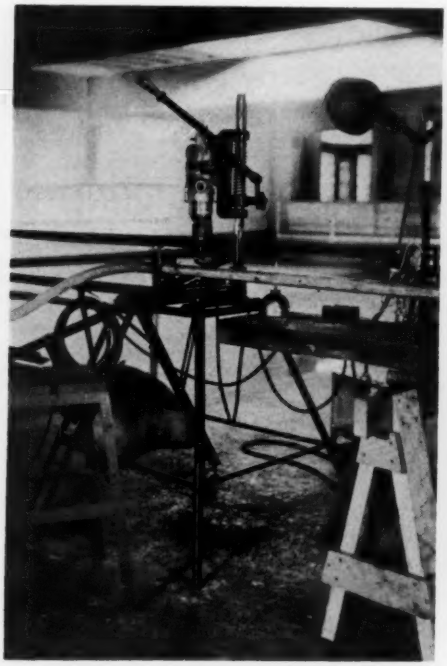

FIG. 5. Holeshooter in Position

FIG. 6. Operation of Reversible Tapper

With the ordinary operators to be found in any filter plant, the overhauling of two filters a week could be completed by using an average of eleven men. During the entire repair job, only one pipe was set at the wrong angle for the holeshooter. The tappers, however, discovered the error; the holes were redrilled, bushed and set in at the correct angle, so that the pipe was used. It proved unnecessary to use the full quantity of new pipe which had originally been estimated.

connections may fail and have to be covered with a "Bitumastic" coating from time to time. No data exist on the corrosion which may be expected on the threads, but if a 15-year life is obtained of the pipes in the surface wash system, the repairs may certainly be considered efficient and inexpensive.

Aftereffects

It has been suggested that the nozzle idea be patented. It is known that several outlets for water type filter

surface wash systems have been patented—one of them at Two Rivers, Wis.

The author has been told that there are commercial and industrial jets for washing out impurities in certain processes, and that these are covered by patents. The alleviation of the gouging and countersinking which affects a straight orifice is explained in these patents as resulting from a vacuum, created by the action of the jets under water, which holds floating sand. No search has been made of the patented features for the possibility of taking out patent rights, but the author believes that the city of Milwaukee should make such a search to protect itself and other cities from patent suits in any new installation of this kind. As a commercial nozzle, patented for an entirely different use—that of lubricating bearings—was used, it is not believed that any patent is being infringed upon. It is known that hundreds of patents have been filed on nozzles for gas burners, sprinkling systems, sprays and many other uses, but no investigation has been made of the number of nozzles patented for the washing of filter sand.

It should be emphasized that the scouring action does not take place when the orifice discharges directly into clear water, but only when it discharges into an expanded material which is hard, durable and free to move about in water. The experiments definitely showed that the sand is sucked into the orifices by the vacuum created by the discharging jet. This causes a whirling action which scoured out a hole much as a spherically shaped countersinker would.

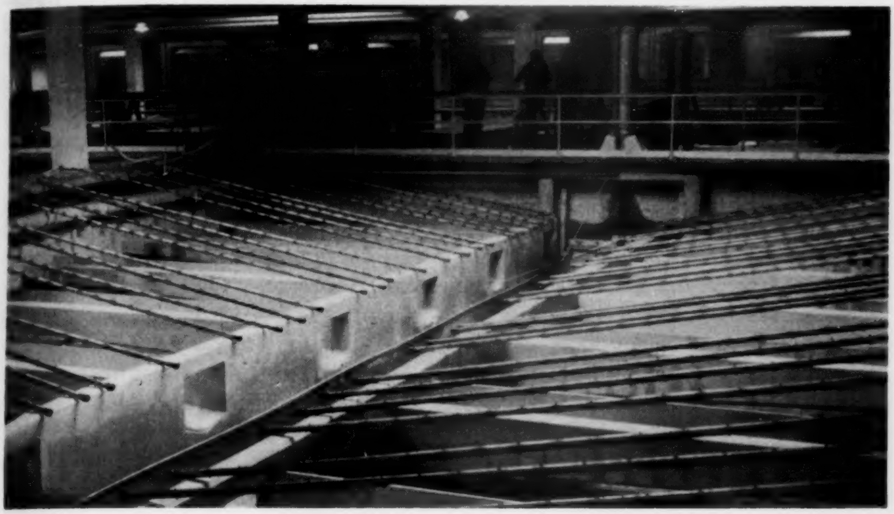

FIG. 7. Completed Wash Pipes Ready for Installation

It should also be noted that expediency forced selection of the nozzle that was available, rather than of any ideally best type. The tests on ordinary plugs showed that, although they could be used for a considerable length of time, they definitely were subject to wear on the flat end, similar to that in an orifice, and that they did not give the pipe the protection that other

types of nozzles did. One of the surprising features of the Milwaukee system was the ease with which the couplings could be opened without injuring the gaskets, once the correct technique had been learned. It was also gratifying that the couplings set back snugly, bringing all the pipes back to their original positions so that they could be clamped in place exactly as they had been. Inasmuch as the Milwaukee plant seems to be alone in having its surface wash pipes parallel to the filter sand, the method of repair in the curved pipes should not be of very great general interest. The experiments with the jets, however, may help other water works engineers to solve their surface wash problems in orifice type systems.

Acknowledgments

The repair of the surface wash system was completed in record time only through the splendid co-operation of the entire staff of operators and mechanics. The author further wishes to acknowledge the splendid co-operation he received from his superiors, H. H. Brown, Supt. of Water Works; J. E. Kerslake, Water Filtration Supt.; and H. B. Hoefer, Chief Engr. of Power Plants.

Yuma and the Colorado River

By C. G. Ekstrom

A paper presented on Oct. 25, 1946, at the California Section Meeting, San Francisco, Calif., by C. G. Ekstrom, District Mgr., Arizona Edison Co., Yuma, Ariz.

YUMA, in the extreme southwestern corner of Arizona, on the Colorado River, is a thriving agricultural community with a population approaching 15,000. Its growth, over the years, has been steady and its citizens prosperous. During the past decade it has experienced a substantial population increase, due in part to the general development of the state of Arizona, but principally to the reclamation of thousands of acres of irrigable land in the lower basin of the Colorado River by the U.S. Bureau of Reclamation.

The early history of Yuma is extremely interesting. For as many years as the Indian stories reach back, this has been the great crossing of the Colorado. Nearly four hundred years ago the Spaniards came to know the Indian trail and then followed the missionaries and later the gold seekers. They found the Indians troublesome, and Fort Yuma was established in 1850 to make the crossing secure. Great herds of cattle were driven overland from Texas and Mexico to be piloted across the river to California by Indian swimmers. The Butterfield stages running from St. Louis to San Francisco, before the Civil War, used the Yuma Ferry. A little later discovery of rich mines in Arizona brought a heavy demand for supplies of all kinds, and Yuma became the distributing point for the southern part of the state, goods coming up the river by boat and moving out by wagon trains. The coming of the Southern Pacific Railroad in 1877 brought a decline in river traffic, although boats still worked up the river from Yuma to nearby rich mining areas.

Agricultural development became important after completion of the 55,000-acre Yuma Project by the Bureau of Reclamation in 1910. This project and other arable lands in the vicinity of Yuma enjoy an all-year growing climate, making possible the production of large amounts of non-competitive crops, such as winter vegetables and fruits.

The climate of Yuma is naturally considered in relation to the surrounding desert. The summers are long and hot, but exceedingly dry atmospheric conditions make them much less oppressive than in many other places in the United States, and for eight months of the year the climate is the most pleasant in the Southwest. The sun does not shine all hours of every day, but it comes nearer doing that in Yuma than in any other part of the nation for which the U.S. Weather Bureau has records.

Ownership of System

The water system of Yuma is owned and operated by the Arizona Edison

Co., Inc. It has never been a municipal undertaking, although several attempts toward municipal ownership have been made. The most recent effort on behalf of the city to acquire the system occurred in 1941, when the voters rejected the proposal by the decisive majority of approximately 3 to 1.

On May 14, 1892, almost at the beginning of the settlement of the community, the village of Yuma granted to Hiram W. Blaisdell a franchise to operate and maintain a water and electric system with conditions of service clearly defined and rates carefully prescribed. To the water operator of today these water rates are quite amusing. For example, the monthly rates for settled water ran as follows:

Single family tenement	\$2.00
Bath tubs (public)	3.00
Bakeries, each 25 bbls. flour	2.00
Stables, each horse	1.00
Horse trough on sidewalk	4.00
Hotels and taverns, each bed	0.15
Saloon, groceries, etc.	4.00
Water closets, public, each	1.50
Water closets, private, each	0.70
Fire plugs, each	5.00

The Colorado River has always been considered the only suitable source of domestic water supply for Yuma. Numerous wells have been drilled in the vicinity over the years, both by the government and many private operators, in an effort to develop good underground water, but always the high salt content of the water rendered the wells useless.

In general, the operation of the water system of Yuma is quite simple. Water is pumped from the Colorado River to a pre-sedimentation basin from which it flows, by gravity in successive stages, through a flash mixer compartment, flocculating chamber, coagulating basin and sand filters to a series of small collecting wells that supply the suction lines to the high-pressure pumps.

Source of Supply

It often used to be said of the Colorado River that it was too thick to pour and too thin to plow; that cowpunchers, after scooping out a hatful of water, would casually watch the hole float downstream. Of course, this is a slight exaggeration, but the silt content of the river, prior to the construction of Boulder and Parker dams above Yuma, varied from a minimum of 1,500 ppm. by weight to a maximum of 55,000 ppm. The huge desilting works of the All-American Canal at Imperial Dam, 18 miles upstream from Yuma, were designed to remove 70,000 tons of silt from the diverted water every 24 hours.

Prior to regulation of the river by Boulder Dam in February of 1935, the variation in stream flow from season to season reached almost unbelievable extremes. On June 2, 1932, the discharge of the Colorado River at Yuma was 89,400 fps. Less than four months later, on September 23, the flow measured a mere 68 fps. Yet despite these seasonal extremes, the bed of the river remained fairly constant at or near 117 ft. above sea level, except for the main channel, which has a habit of shifting back and forth from the Arizona to the California side of the river. Since the construction of Boulder Dam, and more recently of Parker and Imperial Dams, however, the silt load has been dropping out in the reservoirs, and the less turbid waters now flowing past Yuma are causing an appreciable lowering of the river bed at this point. The author's own observations indicate that the bed of the river is now less than 110 ft.

above sea level, or more than 7 ft. lower than it had been.

At a normal stage of the river, the raw water flows by gravity through a 36-in. concrete intake pipe to the low-lift centrifugal pumps that supply the treatment plant. The combined capacity of the four pumps used to lift the water the required 30 ft. is 10,200 gpm.

When, due to controlled operations by the Bureau of Reclamation upstream from Yuma, the stage of the river falls below the intake structure—as it has so often during the recent dry years—water is pumped from a well located directly on the bank of the river with a 20-in. turbine pump capable of delivering 5,000 gpm. against a 40-ft. head.

In order to provide for extreme emergencies, the company has entered into a contract with the Yuma Project, Bureau of Reclamation, for a stand-by source of water supply from the main canal system. This canal originates in California, crosses under the Colorado River through an inverted syphon and reappears in Arizona about 1,200 ft. from the water plant. A 5,000-gpm. turbine pump is installed in the syphon, from which the water is carried to the treatment plant through a 20-in. pipeline.

Treatment Plant

As is usually found in small slow-growing communities, the utility systems of Yuma just grew up with the town, and the water plant was no exception. Years ago, the most practical and economical way to reduce turbidity in water was to put it in a vessel and let it settle. This was the method adopted by Yuma in 1906, using two settling basins each having a storage capacity of 400,000 gal. In 1919 a third basin added 800,000 gal., and in 1928 No. 4 basin was placed in service, adding another 1,000,000 gal. for a total of 2,600,000 gal. of settling basin capacity.

In the succeeding twelve years, or up to 1940, the summer peak demand slowly built up from 900,000 gal. on the maximum day to 2,090,000 gal., and then from 1940 to 1943 it almost doubled when it reached 4 mil.gal.

The four settling basins were operated on a rotating cycle of fill and drawdown, with the retention periods varying with the demand on the system. During the winter months the settling time extended to from eight to ten hours, but during the peak summer season as brief a period as two or three hours was the usual limit. In fact, during the summer of 1943, when demands in excess of 3.5 mil.gal. were met day after day, it was often necessary to apply unsettled water to the filters, which, of course, shortened the filter runs to such an extent that increased settling area or improved methods to settle the water, or both, were vitally needed before the next year.

A turbidity determination showed that the turbidity of the unsettled water was approximately 96 ppm. and the turbidity of the water at the surface of the settling basins after 24 hours of retention was 37 ppm. Therefore, under the method of plant operation then employed, the turbidity was still so high that it would have been necessary to increase the filter area as well as the settling area. For this reason, it was decided to run a series of tests to determine whether the water supply could be treated satisfactorily with a reasonable dosage of coagulant and, if so, what changes in plant would have to be made to accomplish the results desired. As the

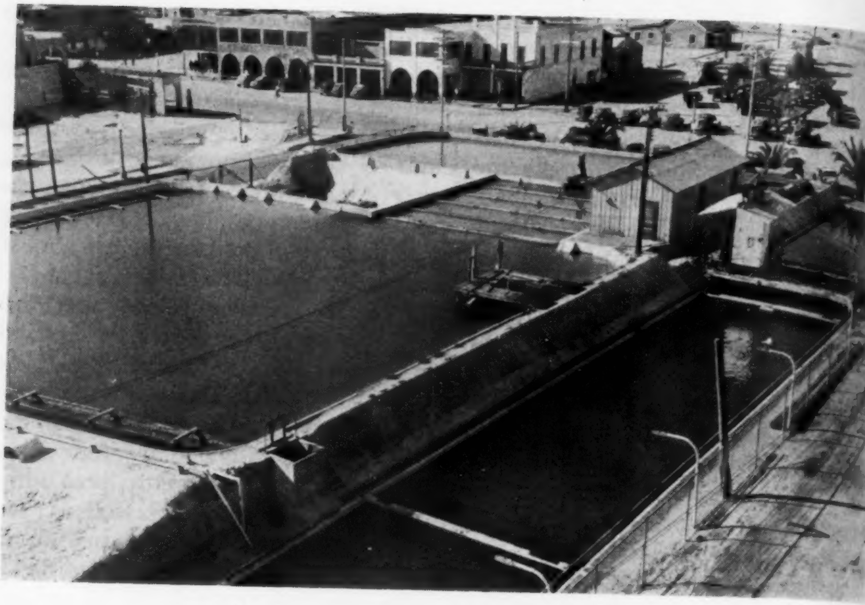

FIG. 1. Reconstructed Basins and Filters

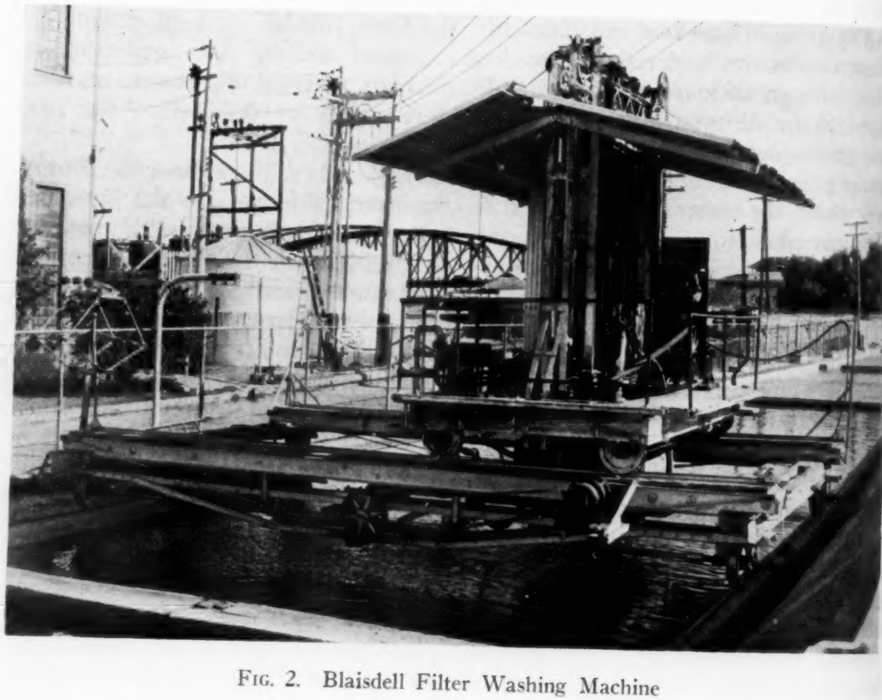

FIG. 2. Blaisdell Filter Washing Machine

company was mainly interested in turbidity reduction from the viewpoint of increasing its plant capacity, the tests were confined to that problem alone and did not include attempts to reduce the hardness of the water or change its chemical characteristics.

It was found that the best results were obtained by the use of aluminum sulfate in the amount of 143 lb. per mil.gal. treated, or 17 ppm. It was also quite evident that, in order to obtain proper flocculation and the development of floc particles sufficiently large for effective sedimentation, the water had to be given a period of flocculation after chemical treatment. With a 15-minute period of flocculation followed by a one-hour period of sedimentation, it was possible to reduce the turbidity of the water from 96 ppm. to 9 ppm., or 91 per cent.

On the basis of these encouraging results, it was decided to proceed with the remodeling of the plant in such a manner as to utilize as much as possible of the existing basins and other facilities and at the same time to keep the plant in continuous operation. The plan called for using No. 1 basin, measuring 48 ft. by 120 ft., as a presedimentation basin where most of the heavy silt would be deposited (rear, Fig. 1).

Number 2 basin, adjacent to No. 1 and having identical dimensions, was to be reconstructed with vertical end walls to accommodate four rows of flocculators 6 ft. 6 in. in diameter and 44 ft. long. The chemical flash mixer was installed in the divided wall between the two basins. The south half of No. 2 basin is still available for additional flocculators when needed (center, Fig. 1).

Number 3 basin, with a surface area measuring 103 ft. by 120 ft., offered a natural arrangement for the sedimentation basin, from which the treated water would flow directly to the filters. In order to prevent short-circuiting of the water from the flocculator compartment to the filter supply lines, a skimming trough 240 ft. long was constructed on the two sides of the sedimentation basin farthest from the flocculators. This trough was made of sections of 36-in. transite pipe cut in half lengthwise and supported on concrete piers (left foreground, Fig. 1).

Number 4 basin was not disturbed in this remodeling program and was the only unit available for settling of the raw water during the period of construction. With the settling area reduced to this one basin, it was imperative that all work in connection with this plant operation be started and completed during the few months of minimum demand between February and May. Construction was started on February 15, 1944, and was completed, and the plant placed in operation, on June 1, 1944, at a cost of approximately $20,000. It is conservatively estimated that the improved plant will handle 6 mgd.

The flocculators and chemical flash mixer were supplied by the Dorr Co., Inc., which also did most of the preliminary engineering work. Wallace & Tiernan Co., Inc., furnished the chemical feeder and Johns-Manville Corp. supplied all of the plant piping and asbestos-cement skimming trough.

The expense of treatment is negligible. Only during the extremely heavy months of June, July and August is it necessary to apply alum at the rate of 17 ppm.; the months of December through March require as little as 8.6 ppm., with an average for the year of slightly less than 13.7. During the year ended August 31, 1946, 910 mil.

gal. of water were treated, using 95,400 lb. of alum at an average cost of $1.92 per mil.gal.

Filters

The filters of the Yuma water plant are of the slow sand filter design with provisions for continuous mechanical washing of the sand. The four filters (shown at the lower right in Fig. 1), which are 25 ft. wide, are arranged end-to-end and total 411 ft. in length for a combined filtering area of 10,275 sq.ft. Each filter consists of 1 ft. of coarse gravel, 6 in. of pea gravel and 18 in. of sand. The filters are kept in continuous operation except during the washing process, when the particular filter being washed is out of service for approximately an hour and a half.

Washing is accomplished by the use of a Blaisdell machine. The same Hiram Blaisdell who secured the first franchise for distributing water in Yuma in 1892 was the patentee of this washing machine, and the unit now in daily service at Yuma was the first one built (right center, Fig. 1; close-up, Fig. 2). On the basis of its successful operation in Yuma, subsequent installations were made in the water plants at Hartford, Conn.; El Centro, Calif.; Wilmington, Del.; Philadelphia, Pa.; Montreal, Que., Can.; and the Eastman Kodak Co., Rochester, N.Y. The author is informed that units were also installed in Europe and Africa.

The operating portion of this machine consists of an inverted metal box about 4 ft. square, in which is operated a revolving rake provided with hollow teeth through which water is forced under pressure. The assembly is supported from a framework which moves the box across the filter. A pump removes water from the metal box at a rate slightly greater than that at which the water is forced out through the revolving teeth, and this muddy water spills into a trough and flows back to the river. The entire machine assembly, moving on rails located the full length of the four filters, is electrically driven from a trolley. The pump, revolving rake, hoisting mechanism and all other movements of the machine are also operated by electric motor drives.

High-Service Pumps

The filtered water is collected in four small clear water wells, one serving each of the four filters, and these wells are connected to a common suction line supplying four DeLaval high-service centrifugal pumps. Chlorine is applied through the suction line immediately ahead of the pumps.

The pumping rate is equalized to a certain extent by the storage of 668,000 gal. in a standpipe situated on a natural elevation about 130 ft. higher than the general service area, but this does not iron out all of the variations in demand on the system. Consequently, the pumps must meet peak conditions in summer and minimum demands in winter.

Distribution System

The principal feeder mains supplying the grid system of smaller mains consist of 7,000 ft. of 8-in., 18,000 ft. of 10-in. and almost 7,000 ft. of 12-in. pipe. The high-service pumps discharge directly into these mains, which are connected to the elevated storage tank that floats on the system. All mains installed since 1937 have been asbestos-cement, class 150 being used in the business section and lower elevations, and class 100 on higher mesa levels. All domestic and the majority

of the commercial services are of 1-in. type "K" copper pipe. The company makes no charge for service connections.

Fire hydrants are owned and maintained by the water company and are not metered, although the use of water is reported and estimated by the city Fire Dept. All other service connections, including water used by the company, are fully metered. The unaccounted-for water varies between 5 and 6 per cent.

Water Rates

The rates charged for water in Yuma are among the lowest in the nation. They have been revised downward six times since the Arizona Edison Co. took over the operation of this property from its predecessors in June 1935. Reductions in water rates have been made effective in 1937, 1939, 1941, 1942, 1945 and, most recently, on June 1, 1946. At the present time, two schedules of water rates are in effect. One is available to all customers and is known as the "general water schedule." It is applicable to all commercial and industrial users and to those domestic customers who benefit by this schedule. The monthly minimum charge is $1.85, which entitles the consumer to use 1,800 cu.ft. of water. For water used in excess of 1,800 cu.ft. per month the charge is 8¢ per 100 cu.ft.

The other schedule is available only to domestic users and is known as the "Optional Residential Rate." It is an attractive schedule for all residential customers who use more water than is provided under the minimum charge of the general rate. This optional rate allows 2,000 cu.ft. of water for a $2.00 minimum charge, 7¢ per 100 cu.ft. for the next 5,500 cu.ft. and 5¢ per 100 cu.ft. for the excess over 7,500 cu.ft. used per month. That this rate is quite popular can be seen from the fact that 40 per cent of the domestic users prefer it to the general rate, even though the minimum charge is slightly higher.

Consumption Data

The per capita domestic consumption in Yuma for the year ending August 1946 was 208 gpd., and the use per domestic customer was 581 gpd. The per capita consumption on a peak summer day exceeds 350 gal. Few, if any, communities, regardless of size, in which all of the water consumption is metered, can equal this high usage.

Long and hot summers with practically no rain during the hot months make it necessary to water lawns and shrubbery from three to four times a week. Some people even irrigate every day, particularly if they try to raise a lawn in the sand without building up the soil with mulch or peat moss. Every effort has been made by the company, through newspaper advertising and educational radio programs, to discourage the waste of water with its resultant high bills, by stressing the importance of proper soil conditioning and reasonable use of water. The company also sponsored the organization of the first garden club in Yuma in 1939. The district now has three active garden clubs that are contributing greatly to the beautification of the city.

Another reason for the high per capita use of water is the use of air-conditioning. The extremely dry atmosphere prevailing through most of the summer is ideal for maximum efficiency from evaporative cooling systems. Hardly a dwelling in Yuma is not equipped with some kind of a wet

pad cooler. Some are crude homemade affairs installed in windows and others are more elaborate, factory-built systems operating through a series of ducts. Numerous recent installations are mechanical refrigeration plants thermostatically controlled, but all of them, large and small, depend on water for cooling and create a heavy demand on the system day and night.

Summary

There are three striking features, it is believed, in Yuma water service experience:

1. The growth in water use has been much greater than the increase in customers. Over a 10-year period which saw a 60 per cent increase in customers, the January sales of water increased 165 per cent, and the July sales, almost 400 per cent. This growth has been almost entirely in the domestic and small commercial classifications, and is attributed by the company to its policy of frequent rate reductions.

2. The growth in water sales has been profitable to the company largely because the necessary increases in plant capacities have been secured at relatively small additional cost.

3. This low cost, in turn, has been due to advances in the art of water treatment, making available processes and methods which could be fitted into the existing plant without the necessity of fundamental changes. The company has been able to take a settling, filtering and treating plant, which ten years ago had apparently reached the limit of its theoretical capacity, and with an expenditure of about $20,000 increase its capacity two and a half times.

The problem was to obtain better settling of the sediment carried in the water of the Colorado River, to handle a greater volume of this water and to speed up the stationary filters. The company's experience, therefore, does not apply to supplies which must change the character of the water or render it softer.

Too often the method employed in making changes is to discard the entire existing plant and build a new plant from the ground up. This procedure is quite pleasing to the eye, but correspondingly hard on the pocketbook of the water company or municipal water system involved. Several years ago when the Yuma water supply was cramped for space and short on capacity, the company contemplated discarding the existing plant and even purchased land for a new one. Before any action was taken on that major project, however, it was discovered that the capacity of the stationary filters could be greatly increased by making changes in the type and distribution of sand and gravel used. These findings encouraged the company engineers to study the problems of settling. Certainly all concerned are pleased, now, that they did not spend the large amount of money a new plant would have entailed.

Waterproofing Concrete Structures

By Nathaniel J. Kendall

A paper presented Oct. 24, 1946, at the California Section Meeting, San Francisco, Calif., by Nathaniel J. Kendall, Engr. of Operations, California Water Service Co., San Jose, Calif.

IMPERMEABLE water storage structures present a most important problem to all water supply engineers and superintendents. This problem should be carefully considered from the inception of any masonry structure designed to hold a head of water, for, normally, masonry is permeable.

Of primary interest to operating men are the existing structures; therefore these receive the most study and consideration. Structures, new or old, which require waterproofing may present a definite hazard not only in the loss of water storage facilities or the water supply, but the safety of life and adjoining property. The operating problems limiting the length of time such a structure may be out of service may, in many cases, result in inadequate repairs and incomplete waterproofing. The availability of materials and manpower and the selection of the methods and means to accomplish the necessary waterproofing present a serious problem, which requires the most thorough study of each structure.

This study can be resolved into two general classifications—waterproofing *before service* and *after service*. A discussion of waterproofing before service concerns the design of new structures, whereas a study of it after service covers the maintenance procedures during use.

Waterproofing Before Service

Integral Waterproofing

There are two main types or methods for waterproofing concrete before it is placed in service—integral and applied. Integral waterproofing is achieved by introducing some substance into the mix to make a concrete of maximum density, thus presenting fewer voids for the percolation of water. The same result may also be accomplished by the incorporation of a water-repellent material. For example, clay makes a lean concrete less permeable by reducing the voids, but it does not add to strength. Hydrated lime makes a mix "fatter," that is, it lubricates the mix so that it is more readily compacted into a dense mass. There are many compounds on the market suitable for use as an admixture in obtaining impermeable concrete. Most of these substances aid impermeability by their property of filling pores upon completion of a chemical reaction which they induce or promote. Additional cement is the best integral waterproofing agent because of its qualities of giving a denser concrete, more strength and permanency.

One of the most recent and successful methods of obtaining a more impermeable concrete is by the use of air-entraining cement or the use of

an air-entraining agent in the mixer (1). Air entrainment in concrete is obtained by a number of classes of materials, such as pine resins, animal or vegetable fats and oils, and certain manufactured patented compounds. These materials are either present in the cement or added at the concrete mixer. Such concrete with its tiny air cells is more resistant to frost and salt action and is less permeable to water. From 2 to 8 per cent air voids in the mix have been the general limit; $2\frac{1}{2}$ to 3 per cent of air voids give about the best impermeability without decrease of strength. The air-entrained cells are of a size equal to the coarser cement particles and finer sand grains, and the sand content is usually decreased in an amount equal to the air voids.

It is possible to make concrete watertight if cracks do not develop because of stress, temperature or the opening up of construction joints. Below-ground structures are affected by temperature relatively little, but those exposed to the weather are very likely to develop leaks through the construction joints. Continuous metal dams across such joints are probably the best solution to this difficulty. Wells about 2 in. by 3 in., filled with a mastic, when used in conjunction with horizontal construction joints, have been successful where floor and wall meet. A reduction of the stresses will lessen the possibility of cracks from that source. To prevent stress cracks, it is particularly important, in reinforcing watertight structures, that sufficient steel be used to eliminate tensile stresses in the concrete, whether or not this steel is needed for stability.

In general, experience has shown that of the integral methods of waterproofing, additional cement will give the best results. This, coupled with a balanced mix of the highest possible density, proper mixing and placing controls, adequate construction joints and sufficient steel, will give impermeable concrete of lasting quality.

Applied Waterproofing

Applied waterproofing is made up of pore-fillers, plasters and membranes. Usually the pore-fillers are used more for damp-proofing than for impermeability. Some of the floor-hardeners and certain proprietary paints and compounds are effective for this purpose. A cement plaster, made with an integral waterproofing agent and applied in thicknesses from $\frac{5}{8}$ in. to 1 in. to the inside surface of walls and floors, has given satisfactory damp-resistant properties. Membrane types of waterproofing have satisfactorily prevented leakage through cracks. Such membranes may be built up of a combination of fabric or paper and asphaltic, bituminous or similar compounds.

Waterproofing After Service

Loss of impermeability, no matter how small, demands an immediate study of the structure. The cause must be determined accurately so that positive corrective action can be taken. The causes are varied, and may include one or more of the following: temperature cracks, stress cracks, opening of construction joints, failure of foundations, earthquakes, original faulty design, age, corrosion, erosion, or mechanical or chemical action. Upon correct diagnosis and determination of the present extent of damage and probable future continuation of such action, a remedy must be selected.

Only the applied method of waterproofing can be used on repairs. A plaster, "gunite," is one of the most

widely used. Gunite may be applied either externally or internally. When applied externally, the whole of the exposed surface is usually treated. This involves laying down a wire mesh and blowing a mixture of sand, cement and water over the surface until the desired thickness is obtained. One inch is about the minimum thickness that should be used. The wire mesh should have sufficient metal to satisfy all temperature stresses, and the surface being treated should have sufficient strength and bearing capacity to withstand all other stresses. Brick-, concrete- and even asphaltic-lined structures have been successfully waterproofed with this process.

Gunite is applied internally by forcing a rich mix into the cavities by means of pipes or tubes. These pipes must frequently be jetted or drilled into position before a satisfactory grouting position can be obtained. This method was successfully used in a limestone region in a shallow lake bed where the water was by-passing the dam through fissures in the rock. A series of grout pipes upstream from the dam, for the full water width, drilled to a sufficient depth and filled with grout under pressure, stopped the leakage. A brick reservoir on an earthquake fault gave continuous trouble, necessitating a yearly winter grouting of cracks and seams from the inside. Increased leakage during the last summer season made it necessary to take immediate action, but heavy summer demands prevented the draining of the reservoir. Grout pipes were therefore jetted under the sloping brick sides and grout pumped in until the cavities were filled.

Internally applied gunite, unless the cavities are large, is usually a straight cement grout. The consistency varies, depending upon the pressure pump and tubes used: the higher the pressure, the thicker the grout. Certain admixtures, such as "Bentonite," have been used successfully with gunite or grout for certain applications.

Cement, dampened to the consistency used in cast-iron bell-and-spigot joints, has given excellent results when calked into cracks which have been chipped and cleaned of all dirt and loose particles.

There are many cement or cement-like products on the market which are, with limitations, suitable and satisfactory for the repair of cracks and construction joints and for general sealing of a concrete surface. Most of these are cement or cement-like products designed to have minimum or minus shrinkage properties upon setting. These products are normally sold at many times the cost of ordinary portland cement, and are advertised to make all porous masonry surfaces watertight. But in reading the directions for application, one finds that there are "unacceptable surfaces," such as those surfaces previously treated with bituminous materials, paints or other compounds, or surfaces having screws or nails thereon; and "unacceptable weather conditions" which affect the results, such as: "rain, hot or cold temperatures, winds or sunshine." In addition, one finds mixing instructions that look like a cake recipe and application directions which exhaust the worker's ingenuity and patience.

The use of such products has resulted in successes and failures. It has been found that a satisfactory job can be obtained only after a painstaking preparation of the surface to be treated. Cracks and joints must be chipped out and wire-brushed, and surfaces must be sand-blasted if dirty,

painted or otherwise treated. All loose particles must be removed, using a wire brush, preferably, and then an air gun; and the clean rough surfaces must be prepared and the product applied as directed by the manufacturer.

A membrane type of covering requires the same careful treatment of the surfaces. One must also bear in mind that many asphalt, bituminous, paint or paint-like products deteriorate under water, are toxic or cause objectionable tastes and odors. Of the membrane types of waterproofing, several products have given satisfactory results when applied by a competent and experienced contractor or under proper supervision. These products are applied hot, and best results are obtained when the surfaces being treated are preheated.

Various clays, such as the bentonites, when used with a protective covering will seal out moisture. This is accomplished by their property of high water adsorption and swelling. They may be used dry, as a putty or as a slurry, depending upon the application.

It should be pointed out that impervious structures are more easily obtained in the original design and construction. Subsequent waterproofing of structures is far more costly than additional cement in the original mix, or better placing of steel to reduce the stresses, or more careful placing of adequate construction joints. If repairs must be made in existing structures, however, a careful study must first be made to determine: (1) the full extent of the damage, (2) probable future recurrence, (3) type of repairs necessary, (4) material best suited to the repairs, (5) precautions required during preparation of the surface to be treated, (6) application procedures and (7) the selection of an experienced contractor or instruction of application personnel.

Whatever the method of waterproofing used, the protection must form a continuous surface and the concrete must be structurally sufficient to resist all stresses due to water pressure.

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Financing Main Extensions

By Donald D. Heffelfinger

A paper presented on Oct. 11, 1946, at the Ohio Section Meeting, Columbus, Ohio, by Donald D. Heffelfinger, Engr.-Supt., Water Dept., Alliance, Ohio.

It is doubtful whether any other water works practice shows more divergent and varied policies than the financing of water main extensions. Talks with water superintendents and a review of the literature on the subject will show that hardly any two policies are alike, and frequently no definite policy exists at all.

The Alliance Water Dept. was one of these systems without a policy. When the war ended, and the accumulated housing shortage was no longer held in check, it was seen that an era of unprecedented building was about to begin, and that it would bring unusual demands for water main extensions. A definite policy of main extension was felt to be necessary for the proper growth and expansion of the water system, and the time was considered ideal for the adoption of such a policy. Water departments want new business, but they should be certain that it is good business. A sound plan, without discouraging real estate developments, will prevent poor and unprofitable investments by the department.

Conditions in the distribution of water have been changing during the past years. Formerly, houses were so crowded together that four or five services could be supplied by 100 ft. of main. Now it is often necessary to lay more than 100 ft. of main for a single customer in outlying regions, so that the cost of investment per customer is steadily increasing. This is further complicated by the fact that a large amount of the new housing is outside of the city limits.

In the past it has been considered good business by some departments to extend water lines if a 5–6 per cent return would be realized on the investment. It was often overlooked, however, that the cost of the extension is only a part of the cost to the department, for pumping station capacity, trunk mains, reservoirs and purification plants must also be considered. For each new customer, an additional load is placed upon the plant and supply works.

It has been stated that, for every dollar invested in distribution mains, approximately two dollars is invested in all other supply facilities, and that 40 per cent of the gross revenue is required to meet operating expenses. Adjusting the revenue return on this basis, a return of 25 per cent on the extension investment is necessary actually to realize 5 per cent.

The various methods of financing mains may be reduced generally to four groups:

1. Special assessment on the property abutting on the mains. This is

the way most sewers and street pavings are financed, on the principle that the property benefitted should pay.

2. Utility investment through appropriation of surplus earnings. In other words, present customers pay higher rates and finance a capital investment to serve future customers.

3. Partial financing (50–100 ft. to the customer) by the utility; the balance paid for by the customer. Gas and electric utilities sometimes use this method.

4. Financing by the customer alone. When the customer pays all or part of the cost, refunds are sometimes made as additional customers are added, or as the revenue warrants.

In Alliance, Ohio, it was felt that a guaranteed return of 2 per cent was adequate and consistent with present interest rates. This amount would yield a return at least equivalent to the cost of financing mains with borrowed money. On this basis, taking into account the factors previously mentioned and the minimum water charge, it was calculated that 50 ft. of 6-in. main per customer could be laid with an assured return of 2 per cent. This plan was adopted for installation within the city limits, the customers paying all costs in excess of the free limit, with refunds made as additional customers are added. The regulations governing extension have been appended to this paper.

Main extensions outside the city offer a somewhat different problem. Should customers inside and outside be treated alike, because other utilities usually do not draw the line? Should surplus funds of a company owned by the taxpayers be used to finance mains for nontaxpayers? Is a city council justified in using the cost of main extensions as a wedge to force suburban areas into the city? These areas often have all of the benefits of urban life without paying a proportionate share.

Financing extensions outside of the city limits is further complicated for those cities not operating under a charter form of government. Section 3969 of the Code of the State of Ohio reads:

> Disposition of Mains and Pipes (paid for by private persons outside city) in case of annexation. The corporation shall take full charge and control of such mains and water pipes, keep them in repair at its own expense, and, in case of annexation to the corporation of such territory, the corporation shall pay to such person or persons a just compensation therefor, and shall thereupon become the owner of them.

Thus if outside lines are laid at customer expense and the territory is annexed, the department must reimburse those having paid for the lines. A real estate promoter may pay for an outside line, receive more for his land as a result and still be reimbursed when the territory is annexed.

It was felt that if the financing of lines inside the city was put on a sound business basis, so ought the financing of lines outside. The plan adopted was to handle all outside lines by written agreement, whereby all costs are paid by the customer, who in the agreement waives all rights under Code Section 3969. In return, whenever the territory is annexed to the city, a refund on the basis of the cost of 50 ft. of 6 in. line per customer will be made. In other words, outside and inside lines are put on the same basis, except that the free limit is not granted on outside lines until the territory is annexed. The form of outside extension agreement has also been appended to this discussion.

Large subdivisions may be referred to the county. Under the direction of the County Sanitary Engineer, a water district is set up. The county contracts for the laying of the main (consulting with the department on size and other details) and will assess the cost on a foot-frontage basis. The county will then enter into a written contract with the city for the latter to furnish water and maintain the lines. The mains remain the property of the county until the territory is taken within the city, and at that time the ownership is turned over to the city at no cost and with no refund to the customers.

Trunk lines have always been financed from surplus earnings or by means of revenue bonds. The size of trunk lines is often primarily decided by the quantity of water necessary for fire protection and part of the cost should really be borne by the general fund of the community, rather than by the water fund. This, however, is seldom done.

Rules, Regulations and Procedure for the Extending of Water Mains

SEC. 1. *Installation of Mains.* No water mains can be installed and connected to the city of Alliance water distribution system by any persons except the Alliance Water Dept., Stark County, or their contractors.

SEC. 2. *Free Limit.* The Water Dept. of the city of Alliance will, upon written application, extend its water distribution system inside the corporate limits of the city of Alliance, Ohio, to serve a new customer or group of customers, provided the extension does not require more than 50 ft. of main per customer.

If the extension is to serve a manufacturing plant or similar customer who will use large quantities of water, the free limit shall be determined by the Director of Public Service; in no case, however, shall the cost of the free limit exceed four times the department's estimate of the annual revenue to be derived from the actual extension.

Should a normal extension inside the city require construction in excess of the free limit described above, the Water Dept. will make the extension, provided the customer or group of customers to be served will deposit with the department in advance an amount equal to the excess of the estimated cost of the extension over the free limit.

In the event the actual cost of the extension is less than the estimated cost, the department will refund to the party or parties making the deposit the amount by which the estimated cost exceeds the actual cost. In no event, however, will the refund exceed the amount deposited.

SEC. 3. *Construction Costs.* The department's estimates of the cost of an extension will include all items of materials and labor —including any extraordinary costs occasioned by opening pavements, rock digging and frost—together with allowances thereon for engineering and general office expense pertaining to the purchase, storage, delivery and installation of all equipment necessary to extend adequate service to the customer or customers to be served from the extension; except that the costs so determined will not include charges occasioned by the installation of a water main larger than would be necessary to meet the customer's or customers' estimated normal requirements, but in no case will computations of costs be based on a main of less diameter than six (6) inches.

SEC. 4. *Extraordinary Investment.* In all cases where, in the opinion of the department, its investment in an extension appears extraordinary or unusual, and where extensive rebuilding or repairing of any facilities is necessary to accommodate the customer or group of customers making application for service, the right is reserved to require the customer or group of customers to be served from the extension to execute a contract for a definite period of service, and otherwise to protect the department against possible losses.

SEC. 5. *Refunds—Additional Customers.* An additional customer on an extension is defined as a customer to whom service can be extended under the "free limit," or at a

lesser contribution per customer than is then outstanding on the existing extension.

In all cases where the costs of taking on a new customer or group of customers exceed the construction costs per customer for the existing extension, the construction necessary to serve the new customer or group of customers will be considered as a new extension.

Should an additional customer or additional customers (as defined above) be added within 10 years to an extension inside the city for which there are then outstanding contributions, the department will refund to the party or parties making the advance, not including the new customer, the cost of a 50-ft. extension for each new customer, this cost to be based on the original cost. The new customer connecting, however, shall pay a connection charge equal to the customer investment in the extension before the new customer is added, but after the adjustment due to the refund by the department because of the new connection, which connection charge will be refunded to all customers on the extension, including the new customers. All connection charges to be based on foot-frontage, and refunds prorated according to amount contributed.

No refund of a contribution received for an extension will be made after ten (10) years from the date service was first established on that extension, and in no case will the total refund to a customer exceed the amount contributed by him.

Sec. 6. *Title.* The title to every extension of mains remains at all times with the Water Dept. The department reserves the right at all times to add additional customers to an extension and to make new extensions to an existing extension under the provisions of these rules without procuring the consent of any party or parties contributing to the original construction costs, and without incurring any liability for refunding on deposits, except as additional customers may be added as provided for herein.

Sec. 7. *Construction Standards.* All construction in water extensions will conform with the department's standards of construction.

Sec. 8. *Extensions Outside City Limits.* The Alliance Water Dept. may extend mains, when requested, beyond the city limits. Such extension shall be made by agreement between the city of Alliance and the party or parties desiring the main extension.

The form and terms of such agreement follow and are made a part of these rules and regulations.

Raymond W. Butler
Director of Public Service

July 17, 1946

Extension Agreement
Extending Mains Outside Corporate Limits of the City of Alliance

An Agreement made and entered into at Alliance, Ohio this — day of ———, 194–, by and between the Alliance City Water Dept., hereinafter called the First Party, and ———, hereinafter called the Second Party.

Witnesseth:

Whereas the Second Party has requested the First Party to extend its water line on, ———,

Now, Therefore, It Is Agreed: That the First Party will extend its water line on the above-named street with ——— inch cast-iron pipe, and the Second Party hereby agrees to pay all labor and material costs required and as determined by the First Party, in advance, with an adjustment made at the completion of the job such that the Second Party will pay the actual cost of the work.

There will be approximately — feet of — inch pipe, — inch valves, — hydrants and various fittings required for the extension.

It is further agreed that after said pipeline is completed, same shall immediately become the sole property of the First Party without further cost, and the Second Party hereby agrees to relinquish all right, title and interest in the said water line to the First Party. In return, the First Party will supply water to the main and will assume full maintenance of the water main, valves and hydrants.

And in further consideration that the city of Alliance will superintend and supervise the laying and extension of water mains and necessary appurtenances and furnish water through said mains to the consumers in such territory, the Second Party does hereby waive and release said First Party from all

claims or demands as such Second Party may or might have under General Code 3969 of the State of Ohio.

In the event a new service is requested and installed on the extension paid for by the Second Party, a front-footage charge will be made by the First Party, and refunded to the Second Party until the Second Party is reimbursed in full, less the proportionate share assumed by the Second Party. This part of the agreement to be in effect for ten (10) years, after which no further refunds will be made.

In the event the territory served by this water main extension is annexed to the city of Alliance within ten (10) years from the date of this agreement, the Water Dept. will refund to the parties contributing to the cost of this extension, the cost of a 50-ft. extension for each customer on this extension, this cost to be based on the original cost of the extension. This refund will be prorated according to the amount contributed. In no event, however, shall the refund to a customer exceed the amount contributed by him.

In Witness Whereof the parties have hereunto set their hands the day and year first above written.

	________________
Witnesses	*Director of Public Service*
________________	________________
	Eng.-Supt. of Water Dept.
________________	________________
	Applicant
	________________
	Address

Publications Report

For the Year Ending December 31, 1946

A report on the publishing activities of the Association submitted to the A.W.W.A. Board of Directors on Jan. 14, 1947, by Eric F. Johnson, Managing Editor, and approved by Harry E. Jordan, Editor.

1. The Journal

a. Text Contents: During 1946, the JOURNAL contained 1,454 pages of papers and abstracts as compared with 1,434 in both 1945 and 1944. Plans to increase the number of pages to 1,800 during the year had to be cancelled as a result of the continued paper shortage and further increases in printing and production costs. Included in the 1946 JOURNAL were the following reports:

(1) Report of the Committee on Meters

(2) Report of the Committee on Watershed Protection and Maintenance

(3) Report of the Publication Committee

(4) Reports of the Committee on Survival and Retirement Experience With Water Works Facilities—9 reports on individual plants

(5) Reports of the Committee on Municipal Water Works Organization —2 progress reports

(6) Report of the Committee on Water Works Practice

(7) Tentative Standard Specifications for Cold Water Meters—Compound Type

(8) Tentative Standard Specifications for Cold Water Meters—Current Type

(9) Tentative Standard Specifications for Field Welding of Steel Water Pipe Joints

The report of the Audit of Association Funds for the Year Ending Dec. 31, 1945, was published in the March 1946 issue. The December issue included a report on the 1946 Conference at St. Louis, a listing of "Papers Scheduled at Section Meetings" and the 1946 JOURNAL "Table of Contents" and indexes.

In addition to the items cited above, 142 articles were published. Of these, 110 were Section Meeting and Annual Conference contributions and 32 were contributions from the field, governmental reports and statutes, editorial statements, etc.

b. Abstracts: A total of 123 pages of abstracts were published during 1946, as compared with 111 pages in 1945. Plans to expand the section to more nearly its prewar size must also be postponed until adequate paper supplies are again available.

c. Advertising: Actual space total of 1946 advertising was 709 pages, compared with 631, 570, 539 and 468 pages, respectively, in the previous four years. The amount of space contracted for 1947 by Dec. 31, 1946, was 649 pages; thus approximately the same amount of space is anticipated for 1947 as was sold last year. In

view of the fact that advertising rates have been increased on an average of 30 per cent as of Jan. 1, 1947, revenue will of course be higher.

The increase in advertising rates, which was made in accordance with the directive of the Executive Committee, was based on an increase in net paid circulation of more than 100 per cent since early 1937 when the previous rate card became effective. The new advertising rate is only the second revision of rates in the 33-year life of the JOURNAL.

d. Total Pages: The total of the above cited pages, including News of the Field and the information at the front of each issue, was 2,450 pages compared with 2,358 pages in 1945. Adding the 256-page Membership Directory, a total of 2,706 pages were published in comparison with 2,436 pages in 1944, the last previous year in which a directory was issued.

e. Printing: Beginning in August 1946, an additional 12 per cent surcharge was made on composition, presswork, binding and mailing of the JOURNAL. This, added to the 10 per cent surcharge imposed in February 1944, made the over-all increase in printing costs 22 per cent over 1943.

In 1946, an average of 7,308 copies was printed monthly compared with 6,518 in 1945 and 6,188 in 1944. The printing order for January 1947 was 7,650 copies.

The total cost of JOURNAL printing and production in 1946 was $24,583.42 compared with $23,039.47 in 1945. Despite the increase in printing costs mentioned above, and despite slightly higher costs of drafting and engraving, the unit costs of printing and production were held below those of 1945. This was made possible by a reduction in the number of pages of expensive tabular material, particularly in the Survival and Retirement reports, and by savings in the general production costs. Thus, in spite of a severe increase in the cost of paper used, over-all costs per 1,000 pages were reduced from $1.770 in 1945 to $1.705 in 1946. Over-all cost per copy was $0.355 in 1945 and $0.356 in 1946.

f. Paper Stock: Despite the lifting of OPA price ceilings late in the year, paper stock was very difficult to obtain throughout 1946, and little improvement is expected in the near future. As matters now stand, the supplier of the past few years has continued to provide approximately 30 tons of paper annually on a small-lot-at-a-time basis, but it has been impossible to supplement that supply through small-lot purchases from other suppliers. Because approximately 10 per cent more JOURNAL was printed and because it was necessary to use approximately 3½ tons of JOURNAL paper stock in printing the Membership Directory, the situation now necessitates a further reduction in JOURNAL size, at least for the immediate future.

Another year of small-lot purchasing saw prices increase with virtually every shipment, so that the average price of paper during the year was 20 per cent higher than in 1945. The various increases in paper cost since 1943 have brought the price level at the end of 1946 up to 158 per cent of the 1943 price.

2. 1946 Membership Directory

A biennial Membership Directory of 256 pages was issued with the November JOURNAL. Although it had been planned to make the directory pages available for advertising, the paper shortage made it necessary to cancel those plans. Increased print-

ing, production and paper costs together with the decision to use a larger type size for the individual listings raised the cost of directory publication above the budgeted allowance. Total publication cost was $4,046.71, representing a cost of $1.775 per 1,000 pages, or $0.421 per copy.

3. Index to the Journal

Of the 1881–1939 Index, 280 copies remain in stock after a 1946 sale of 19 copies. In 1945, sales totaled 34 copies.

4. Standard Methods for the Examination of Water and Sewage

The ninth edition of *Standard Methods,* after delays due to the paper shortage, has cleared the presses and awaits the adjustment of supply difficulties in the bindery. Its issuance during January 1947 appears assured.

5. Manual of Water Works Accounting

In 1946, 21 copies of this text were sold, compared with the 31 copies sold during 1945.

6. Specifications

During the year tentative specifications for current and compound type meters were made available, as were tentative specifications for field welding of steel water pipe joints. The specifications for displacement type meters and for deep wells were advanced to standard status. Sales, particularly of the various meter specifications, have indicated an increased use of A.W.W.A. standards throughout the field.

7. The Manual of Water Quality and Treatment

The preliminary draft of the entire manual has been prepared, circulated and criticized. The material is now in the hands of an Editorial Co-ordinator, who is charged with the duty of final revision of the separate chapters into a unified document.

8. Survival and Retirement Experience With Water Works Facilities

All text for the compilation of reports is now in type. Page proofs on the first pages have been received. Paper stock now on order has been shipped. The printer has been directed to print 3,000 copies, of which he is to bind 2,000 and hold 1,000 copies collated subject to later orders for binding. When the 3,000 copies have been printed, the type will be torn down, as, in the judgment of the editor, there is no possibility of further demand for this unique and valuable study. The 576-page volume will be sold for $3.00 per copy. This low price could not be established if the expensive job of tabular typesetting had not already been charged to the Journal.

9. History of Water Purification

It has been necessary to suspend final printing of this book until satisfactory paper stock and cover cloth can be procured. If conditions improve the volume can be released during 1947.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1946

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1946, submitted to the A.W.W.A. Board of Directors Jan. 13–14, 1947, by Malcolm Pirnie, Chairman.

THE activities of the Committee on Water Works Practice and its subcommittees during the year 1946 are herewith summarized.

Water Works Practice Subcommittees

1. *Deep Wells and Deep-Well Pumps.* The specifications for deep wells were reviewed at the meeting of the Board of Directors in May 1946. The committee was instructed to modify certain references to guaranteed well contracts. This was done, the revised text approved by the Board and the specifications advanced to *standard* as of Oct. 1, 1946. The specifications for Deep-Well Pumps have not yet been completed.

2. *Watershed Protection and Maintenance.* A complete session during the St. Louis Conference was given over to this committee. Organization of its Subcommittees has been perfected, and Chairman Boyce plans to develop certain statistical data concerning impounding reservoirs during the coming year.

3. *Steel Pipe and Coatings.* Chairman Hurlbut has under way certain minor revisions of the specifications for large diameter electric welded pipe. Work is also proceeding on the *Manual of Design and Installation of Steel Water Pipe.* The chairman has developed and presented to the committee certain policies on materials for protection of steel surfaces that are important enough to be recorded here: "The committee will not consider materials by proprietary or brand names. The producer of material must prepare and submit descriptive specifications for his product which will cover control of quality of ingredients as well as performance of the material. A product submitted for approval must have a record of at least five years' prior use in the water works field. A list of users should be submitted. There should also be submitted to the committee a record of appropriate tests which have been made upon the material—such as water absorption, resistance to soil stress, temperature characteristics—which will afford a precise basis of comparison of the submitted material with other materials already in use in the water works field."

4. *Reinforced Concrete Pipe.* A new document entitled "Tentative Standard Specifications for Reinforced Concrete Pipe (With Steel Cylinder—Prestressed)" has been prepared and sent for review to the subcommittee by Chairman Whitlock. The material is now being put into form for submission to the Committee on Water Works Practice.

5. *Fire Hydrants.* The committee has had several conferences during the year in an attempt to reconcile opposing viewpoints concerning the proper strength of the hydrant stem. The corresponding committee of the N.F.P.A. is co-operating with the A.W.W.A. group in order to develop specifications for the two organizations which will be in technical accord.

6. *Valves.* The chairman of the committee proposes to present the revised text of the specifications for approval prior to midyear 1947.

7. *Sluice Gates.* William R. Conard, previous chairman of this committee, died during 1946. The new chairman is Thomas J. Skinker, Supt. of the St. Louis Water Dept. The committee is at present engaged in a review of certain criticisms of the tentative specifications to ascertain what modifications are necessary.

8. *Laying Cast-Iron Pipe.* Chairman Schwada advises that the final draft of the specifications revision is now in preparation. The chairman has raised certain issues, concerning the use of plastic sulfur jointing material, that have been discussed in conference of Malcolm Pirnie and T. H. Wiggin with the manufacturers of plastic sulfur compounds. This is a subject for board discussion.

9. *Disinfection of Water Mains.* The recommended practice manual upon this subject has been cleared through the subcommittee by Chairman Calvert. It has been approved by the Committee on Water Works Practice and, when approved by the board, will be published in the JOURNAL.

10. *Distribution System Safety.* Chairman Stanley requested that the section officers promote discussions of this subject in meetings held during 1946 as a guide to the committee in its development of a manual of practice. The material derived from these discussions is not extensive, but is being used by the chairman as a guide to the conduct of the project.

11. *Meters.* Specifications for Cold Water Meters—Displacement Type are now *standard*. Specifications for Compound and Current Meters have been published in *tentative* form. The specifications for Fire Service Meters have been approved as *tentative* and were published in the February JOURNAL [pp. 173–183].

12. *Service Line Materials.* The report of this committee, which had been withheld during the war, is now being revised by Chairman Peirce. It will be cleared for publication during 1947.

13. *Recommended Standard Threads for Underground Service Line Fittings.* Excellent progress has been made on this difficult assignment by Chairman Brush and his committee. A statement from the chairman forms Appendix A to this report.

14. *Radio Facilities for Water Works.* The advisor, A. Damiano, has participated in the hearings on the subject matter before the FCC during 1946. The regulations promulgated by the FCC have been published in the JOURNAL (p. 1398, Dec. 1946 issue). It now appears advisable to set up a standing subcommittee on radio facilities, selecting the committee personnel from water utilities in various parts of the country where such equipment is being used.

15. The Subcommittees on Cross-Connections, Fire Prevention and Protection, Valve Boxes and Covers, Electrolysis, and Valuation and Depreciation have not been active during 1946.

Water Purification Division Committees

16. *Water Purification Chemicals.* The Executive Committee of the Division is actively engaged in final revision of the separate sections of this important project.

17. *Distribution System Problems.* The committee has discussed fully its methods of procedure, but no studies have as yet been carried on.

18. *Testing Zeolites.* The committee has been reorganized under Chairman Davis, but no revision of the present *Manual* has been developed.

19. *Loading Capacities of Purification Units.* This committee has been completely reorganized during 1946 with H. O. Hartung as chairman. Good progress is being made toward a preliminary report.

20. *Methods to Inhibit Corrosion.* This committee has been reorganized with C. P. Hoover as chairman, and is actively at work.

21. *Filtering Materials.* Chairman Hazen has developed a preliminary report for his group and is making good progress.

22. *Open-Air Reservoirs.* This is a new committee, with Norman Howard as chairman. The committee is active.

23. *Disposal of Water Purification Wastes.* W. W. Aultman is chairman of this new committee. Limitations that have been established in certain states upon disposal of sludge from purification plants make this committee's work most important.

23. *Joint Administration of Water and Sewer Accounts.* An active discussion of the problems within the scope of the committee's activity was a part of the St. Louis Conference program. The committee proposes to continue to collect information concerning the practices in various cities where water and sewer accounts are jointly administered.

Joint Committees With Other Organizations

24. *Water and Sewage Examination Methods.* The ninth edition of the text was released by the printer in January 1947.

25. *Boiler Feedwater Studies.* This committee has been reactivated under the chairmanship of C. H. Fellows.

26. *Co-ordinating Committee on Corrosion.* This group is now studying its plans for future activity.

27. *Standard Form of Construction Contracts.* Efforts to reactivate this committee have thus far been unsuccessful.

28. *Research Committee on Grounding.* This committee is inactive.

29. *Glossary—Water and Sewage Engineering.* This text is now being typeset by the printer and reviewed by representatives of the co-operating associations.

30. *Field Welding of Steel Water Pipe.* The Tentative Specifications were published in the March 1946 Journal. Minor revisions are now under consideration by the committee under Chairman Hurlbut's direction.

31. *Survival and Retirement Experience.* The studies made under the direction of this committee have been completed and all but one were published in the Journal during 1945 and 1946. The entire series of reports is now being printed as a single volume. Three thousand copies will be printed, the type torn down, and two thousand copies bound. Orders for approximately this entire number are now in hand. The balance of one thousand copies will be held unbound

in the plant of the printer until a more favorable time for binding.

32. *Steel Standpipes and Elevated Tanks.* This committee, during the current year, has been:

a. Keeping a general contact on the tank racket situation, mainly through correspondence.

b. Keeping up to date with the changes in welding practice and specifications affecting tank construction in order to revise the A.W.W.A.–A.W.S. specifications in line with the latest procedure when the next printing of the specifications is made.

c. Similarly keeping in contact with changes in A.S.T.M. specifications on steel that will affect the availability of materials and the specifications when next rewritten.

The committee has not brought any projects to completion during the year, although some further consideration has been given to the development of standard specifications for repainting of standpipes and tanks. Completion of those specifications has been delayed by the chairman's schedule.

33. *Standard Dimensions of Flanges for Steel Water Pipe.* This committee has made a survey among users, consultants and manufacturers covering preferred flange and drilling dimensions. The report of this survey is now being reviewed by a special subcommittee.

34. *Correlating Committee on Cathodic Protection.* This inter-association committee (American Assn. of Railroads; American Gas Assn.; American Petroleum Inst.; American Telephone & Telegraph Co.; National Assn. of Corrosion Engineers; Western Union Telegraph Co.; American Water Works Assn.) held an organization meeting in August 1946. H. H. Anderson of the American Petroleum Inst. was named chairman, and F. E. Dolson of the A.W.W.A. was made secretary. Certain preliminary outlines of scope and procedure have been formulated. It appeared desirable for the A.W.W.A. to record its firm intention to continue to co-operate in this project, since the increased use of cathodic protection of underground pipelines gives promise of producing certain difficulties as well as great benefits to the owners of the lines thus protected.

Committees on Which the A.W.W.A. Has Representation

35. *Cast-Iron Pipe and Special Castings.* A special communication from Chairman Wiggin is attached as Appendix B to this report. A board resolution on the subject is attached as Appendix C.

36. *National Electrical Code.* The 1947 Electrical Code contains sections which were adopted by the Committee over the protest of C. F. Meyerherm, the A.W.W.A. representative on the Grounding Subcommittee. Since the sections to which the objections were made tend to extend the area of derivation of current which may find its way to water service lines, the Board is expected to adopt a resolution upon the subject.

37. *Pipe Flanges and Fittings.* During 1946, this committee approved the "American Standard for Socket Welding Type Steel Fittings." Also during the year American Standard B16e2–1936, Pipe Plugs of Cast Iron, Steel, etc., was officially cancelled. No other document under the committee's charge changed status during the year.

38. *Graphical Symbols for Use on Drawings.* Graphical symbols for Electric Power and Control were completed and issued in 1946. A valuable

document, "Abbreviations for Use on Drawings," was issued in preliminary form during the year.

39. The A.W.W.A. is represented in a series of committees of the A.S.A., the N.F.P.A. and the Bureau of Standards which have not completed any projects during 1946. These committees are listed for the record:

American Standards Association

A35—Manhole Frames and Covers

A40—Standardization of Plumbing Equipment

B2—Pipe Thread

B31—Code for Pressure Piping

Z10—Letter Symbols and Abbreviations for Science and Engineering

Z23—Specifications for Sieves for Testing Purposes

National Fire Protection Association

Forests

Public Water Supplies for Private Fire Protection

Elevated Tanks

Bureau of Standards

Wrought Iron and Wrought Steel Pipe, Valves and Fittings

Your chairman, in concluding this report, observes that it has been his privilege to serve the Association on this committee continuously for twenty-five years, first as secretary under George W. Fuller's leadership and later as chairman. Each year has found the members of the Subcommittees producing one or more standards documents which have been of value to the Association. Each year has likewise found some Subcommittees which have not been able to function satisfactorily. But the net result of the work of the activities of the Committee on Water Works Practice has been a substantial and permanent lifting of the standards of water works construction and service. It is a source of personal satisfaction to have been able to serve the American water works profession during these years in the work of the committee.

Appendix A

Threads for Underground Water Works Fittings

A statement by William W. Brush, Chairman, Committee 7T—Recommended Standards for Threads for Underground Service Line Fittings.

The committee was organized with advisory consumer members to represent virtually all of the A.W.W.A. Sections. A manufacturers' advisory committee was not organized, as it was believed that the work of Committee 7T could be better developed by securing the co-operation of the individual manufacturers than by working through a committee of manufacturers. As its technical thread consultant, the committee secured W. H. Gourlie, President of the W. H. Gourlie Co., Hartford, Conn., who has been very active in the promotion of thread standardization, both nationally and internationally.

The committee had available at the start of its work the proposed threads for underground water works fittings that had been worked out by the American Standards Assn. subcommittee on that subject. This ASA subcommittee had submitted proposed threads to the ASA thread committee in 1932, but no action has been taken by the ASA sectional committee.

Based largely on the 1932 proposals, a tentative new schedule of threads with proposed tolerances and other details was submitted to the manufacturers in the spring of 1946 and discussed at a meet-

ing that was held in St. Louis during the A.W.W.A. Annual Conference in May 1946.

The manufacturers pointed out that the proposed threads would not be in line with existing practice in the water works field and asked to have these threads reconsidered. For the guidance of the committee, the four manufacturers who make the greater part of the fittings used by the water works systems agreed to furnish the details of the threads used by them on the various fittings.

This information was supplied during the summer and early fall. Using the information given, Mr. Gourlie drew up a new schedule of threads, tolerances and other details which is soon to be submitted to the manufacturers for their comments.

This new schedule very closely follows the general thread practice of the industry, and it is believed that the manufacturers and the consumer committee members will find the proposed threads generally acceptable.

If it is found that only minor changes need to be made, the committee should complete its activities and submit a final report to the Water Works Practice Committee in time for that body either to arrange for a letter ballot on the acceptance of the proposed standards by the Board of Directors, or else to have the proposed standards considered at the San Francisco Conference.

Appendix B

ASA Committee A21—Cast-Iron Pipe Specifications

Excerpt from a letter dated Dec. 26, 1946, from Edward Hubbard, Specification Engr., Los Angeles Dept. of Water and Power, to Harry E. Jordan.

Checking over the proposed Supplement No. 2 to the 1942 Edition of American Standard Code for Pressure Piping, it was forcibly brought to my mind that the American Water Works Association does not have standard specifications for centrifugally-cast cast-iron water pipe. I do not know why this is so, but I have been informed indirectly that this condition is due to the failure of agreement among some of the manufacturers of cast-iron water pipe. My experience with specifications here in the Water Department has been that it is unsatisfactory to try to combine apparently identical materials produced by different manufacturing methods under one set of specifications. I suggest that if the American Water Works Association cannot approve Federal Specifications W.W.P.-421 in its entirety as A.W.W.A. Standard Specifications, we should show some activity and have Standard Specifications on the one commodity that is used to a larger extent than any other.

Excerpt from a letter dated Jan. 2, 1947, from Thomas H. Wiggin, Chairman, ASA Committee A21, to Harry E. Jordan.

This matter of lack of progress on specifications for pipes (other than pit-cast) and fittings has been the subject of considerable correspondence and discussion with you over a period of several years, so that I need not rehearse the reasons for our inability to agree upon specifications for pipe other than pit-cast. I will, however, bring you up-to-date, which I have been intending to do in response to your circular letter covering the activities of committees.

A great deal of apparent progress was made at a meeting in May 1944, but since that time the producers have made several other suggestions in substantial modification of what was thought in 1944 to have been a near agreement. These new suggestions have been discussed in several meetings of a consumer group which has kept in contact with the producers.

It was the consensus of opinion of this group that the meeting with the producers planned for 1946 would not be profitable because of the peculiar business conditions.

Contacts have been renewed within the past month and a meeting preliminary to the full committee meeting has been set for the fourth week in January.

With respect to fittings, incomplete reports of bursting tests indicated to me that considerable redesigning should be done to the present A.W.W.A. standards for fittings. Since the beginning of the war, however, no progress has been made in determining in detail what those changes should be, and repeated inquiries made of the producers have invariably elicited the response that they have been unable to resume the expensive bursting experiments upon the completion of which depended their recommendations of changes in design. This matter is in a less satisfactory state than that of the straight pipe because the producers have been unwilling to publish for the benefit of the whole committee the results of their rather disappointing bursting tests of large fittings. I think it will be obvious that a continuation of these expensive tests is not something which it is easy to demand; rather, it is something which is likely to come only with a more settled condition of business.

Returning to the question of specifications for pipe other than pit-cast, these could be completed at any time by making concessions that, in the opinion of a consumer group consisting of engineers whose opinion I am sure would be generally respected, go beyond what should be conceded. I can assure you that this group has a very lively sense of its obligations to complete these specifications and has repeatedly examined the points of difference with a view to going as far as possible in meeting the views of the producers.

Appendix C

Resolution of Board of Directors

A resolution adopted by the A.W.W.A. Board of Directors Jan. 14, 1947, on the subject of specifications for cast-iron pipe and special castings.

1. The Board of Directors of the American Water Works Association, at its annual meeting Jan. 14, 1947, has taken note of the fact that, twenty years ago, the Association joined with the New England Water Works Association, the American Gas Association and the American Society for Testing Materials in the organization of the American Standards Association Committee A21—Cast-Iron Pipe and Fittings.

2. Under the continuous chairmanship of Thomas H. Wiggin and with the co-operation of the manufacturers of cast-iron pipe, the committee has been able to conduct a series of research projects and to base upon these studies certain specifications which, since 1939, have been the recognized basis of production and purchase of pit-cast cast-iron pipe.

3. The Board observes that the committee has for several years had in development A.S.A. standards for centrifugally cast pipe and new standards for cast-iron fittings. It regrets to note that neither one of these standards has as yet been brought to the state of consensus necessary for its completion.

4. The Board understands that the failure to complete these projects results from the inability of the manufacturers to reach an accord. This is regrettable since it is recognized that, in the earlier years of the committee's work, the willingness of the producers to co-operate in the enterprise was a most important factor in the success of the committee.

5. The Board holds the firm opinion that the water works field is clearly entitled to have available to it an Ameri-

can Standard Specification for centrifugally cast iron pipe, since this material has been found of great value in water works installations and should not continue to be purchasable only upon a commercial specification basis.

6. The Board therefore conveys to the chairman of the committee—Mr. Wiggin—its full appreciation for the services which he has rendered to the water works industry. To the manufacturers who have so well co-operated in the past work of the committee, the Board expresses the considered opinion that full effort should be made to develop an accord in these important projects of the committee and the users of cast-iron pipe be enabled to purchase centrifugally cast pipe and cast-iron pipe fittings in accord with new A.S.A. specifications not later than the beginning of 1948.

7. The Secretary is hereby directed to send copies of this statement to the chairman of the A.S.A. Committee A21 and to the Secretaries of the three other sponsor associations.

Report of the Audit of Association Funds

For the Year Ending December 31, 1946

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have an annual audit made of the books of the Association.

The records for 1946 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared in the JOURNAL as follows: pp. 520–25, March 1938; pp. 570–74, March 1939; pp. 516–20, March 1940; pp. 774–78, April 1941; pp. 426–30, March 1942; pp. 338–42, March 1943; pp. 359–63, March 1944; pp. 317–21, March 1945; and pp. 386–90, March 1946.

Respectfully submitted,
HARRY E. JORDAN
Secretary

February 3, 1947

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of Dec. 31, 1946, and the statements of income and expenses and surplus for the year then ended, have reviewed the system of internal control and the accounting procedures of the Association and, without making a detailed audit of the transactions, have examined or tested accounting records of the Association and other supporting evidence by methods and to the extent we deemed appropriate. Our examination was made in accordance with generally accepted auditing standards applicable in the circumstances and included all procedures which we considered necessary.

In our opinion, the accompanying balance sheet and related statements of income and expenses and surplus present fairly the position of the American Water Works Association at Dec. 31, 1946, and the results of its operations for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—Balance Sheet, December 31, 1946

Assets

Cash in Banks and on Hand		$23,057.44*
Accounts Receivable:		
Advertising	$2,712.25	
Reprints	508.67	
Other	42.22	3,263.14
Membership Dues		126.97
Accrued Interest on Bonds		467.12
Inventories:		
Paper stock	$2,499.31	
Type metal	572.25	
Cumulative Index (279 copies)	334.80	
Manual of Water Works Accounting (24 copies)	34.80	
Sundry publications	537.38	
Membership certificates	28.18	
Fuller Memorial Award certificates	16.22	
Back issues—Journals—Vol. 1 to 38, inclusive (33,136 copies)	—†	
Back issues—Proceedings—1881 to 1913, inclusive (271 copies)	—†	4,022.94
Office Equipment (Less depreciation)		4,234.88
Investments at Cost, including excess of redemption value of U. S. Savings Bonds over issue price (quoted market value Dec. 31, 1946: $115,398) per Schedule 1		116,421.36
1947 Convention Expense		168.55
Deposits		1,335.00
Total Assets		$153,097.40

Liabilities and Surplus

Accounts Payable	$ 2,859.08
Membership Dues—Advance Payments	16,901.74
Unearned Subscriptions to Journal	1,634.25
Reserve for Award Fund (McCord)	53.02
Surplus, per Exhibit C	131,649.31*
Total Liabilities and Surplus	$153,097.40

* Canadian funds in the Bank of Montreal as at Dec. 31, 1946, amounted to $839.35, which, if converted into currency at that date, would have resulted in a loss of approximately $41.96. Had this loss been recorded, the cash in banks and the surplus would have been decreased accordingly.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication.

EXHIBIT A, Schedule 1—Investments—December 31, 1945

Description	Interest Rate, %	Principal Amount	Cost	Quoted Market Value 12/31/46
City of Los Angeles	3½	$2,000.00	$2,241.11	$2,360.00
Province of British Columbia	4½	1,000.00	1,000.00	1,090.00
Province of Ontario	4	1,000.00	732.50	1,175.00
Canadian Victory Bonds	3	6,000.00	5,647.75	6,030.00
Canadian Victory Bonds	3	2,000.00	2,000.00	1,990.00
Canadian Victory Bonds	1¾	2,000.00	2,000.00	1,990.00
Canadian Victory Bonds	1¾	5,000.00	5,040.00	4,975.00
U. S. Savings Bonds—Series C	2.9*	7,000.00	5,250.00	6,860.00†
U. S. Savings Bonds—Series C	2.9*	10,000.00	7,500.00	9,200.00†
U. S. Savings Bonds—Series D	2.9*	10,000.00	7,500.00	9,000.00†
U. S. Savings Bonds—Series D	2.9*	10,000.00	7,500.00	8,700.00†
U. S. Savings Bonds—Series G	2½	10,000.00	10,000.00	9,490.00†
U. S. Savings Bonds—Series G	2½	2,000.00	2,000.00	1,894.00†
U. S. Savings Bonds—Series G	2½	5,000.00	5,000.00	4,740.00†
U. S. Savings Bonds—Series G	2½	10,000.00	10,000.00	9,620.00†
U. S. Savings Bonds—Series G	2½	2,000.00	2,000.00	1,924.00†
U. S. Savings Bonds—Series G	2½	10,000.00	10,000.00	9,690.00†
U. S. Savings Bonds—Series G	2½	3,000.00	3,000.00	2,934.00†
U. S. Savings Bonds—Series G	2½	2,000.00	2,000.00	1,976.00‡
U. S. Savings Bonds—Series G	2½	20,000.00	20,000.00	19,760.00‡
Excess of redemption value of U. S. Savings Bonds, Series C and D. over issue price			6,010.00	
			$116,421.36	$115,398.00

* Yield, if held to maturity. † Current redemption value. ‡ Redeemable at the amount shown on June 1, 1947.

EXHIBIT B—Statement of Income and Expenses for Year Ended December 31, 1946

Operating Income:		
Annual dues	$61,841.30	
Advertising	41,271.50	
Subscriptions to Journal	4,672.23	
Convention registration fees	8,904.59	
Convention—other events	492.25	
Water and Sewage Works Mfrs. Association	7,500.00	
Interest on investments	3,208.46*	
John M. Goodell prize	75.00	
Miscellaneous interest income	19.35	
Total Operating Income		$127,984.68
Publication Income:		
Manual of Water Works Practice	$ 60.00	
Manual of Water Quality and Treatment	0.26†	
Manual of Water Works Accounting	83.85	
Reprints	2,203.54	
Cumulative Index	43.50	
Membership Certificates	68.00	
Proceedings and Journals	1,210.70	
Total Publication Income (carried forward)		3,669.33
Total Income (carried forward)		131,654.01

* This account includes:	Profit on sale of Province of Ontario bonds	$ 310.00
	Loss on sale of U. S. Certificate of Indebtedness	5.15
	Increment in redemption value on U. S. Savings Bonds for 1946	1,180.00

† Denotes red figures.

Total Publication Income (brought forward)			$ 3,669.33
Total Income (brought forward)			131,654.01
Specifications:			
Miscellaneous		$ 483.50	
Meters		428.95	
Cast-iron pipe		156.07	
Steel pipe		440.73	
Elevated steel tanks		141.25	
Repainting tanks		22.60	
Gate valves		41.00	
Fire hydrants		30.10	
Wells and well pumps		20.35	
Sluice gates		8.55	
Total Publication Income			5,442.43
Total Income			$133,427.11
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$ 3,469.66		
Stenographic expense	152.40		
Executive committee meetings	131.69	$ 3,753.75	
Administrative Expenses:			
Rent	4,100.00		
Office supplies and services	6,348.24		
Membership promotion	577.17		
Legal and auditing expense	1,513.86	12,539.27	
Administrative Salaries		37,512.36	
Committee Expense		504.36	
Division and Section Expense:			
Division expense	$ 16.67		
Section—membership allotment	8,628.96		
Section—official travel	4,928.78		
Section—general expense	491.75	14,066.16	
Journal:			
Printing	$20,881.73		
Production	3,728.66		
Paper	6,451.15		
Abstractors	205.32		
Directory	3,810.86	35,077.72	
Convention:			
General	$ 3,627.28		
Entertainment	6,871.40		
Management committee	176.85		
Publicity	200.00	10,875.53	
Membership Dues in Other Associations		875.00	
John M. Goodell Prize		75.00	
Depreciation of Office Equipment		792.18	
Miscellaneous Expense		735.02	
Total Operating Expenses (carried forward)		$116,806.35	
Total Income (carried forward)			133,427.11

Total Expenses and Income (brought forward)		$116,806.35	$133,427.11
Cost of Publications Sold:			
Manual of Water Quality and Treatment	$ 48.44		
Manual of Water Works Practice	44.00		
Manual of Water Works Accounting	33.35		
Reprints	1,705.09		
Cumulative Index	22.80		
History of Water Purification	304.37		
Membership Certificates, including lettering and mailing	51.80		
Journals and Proceedings	292.50		
Fuller Award Certificates	10.34		
Water Works Retirement	137.41		
Specifications:			
Miscellaneous	86.82		
Meters	254.18		
Cast-iron pipe	224.52		
Steel pipe	302.08		
Elevated steel tanks	182.69		
Repainting tanks	30.39		
Gate valves	4.24*		
Fire hydrants	9.14		
Sluice gates	13.87		
Wells and well pumps	40.56		
Service fittings	270.94		
Total Cost of Publications Sold		4,061.05	
Development Expense—Research:			
Glossary—Water and Sewage Control Engineering	332.00		
Federal activities	450.79		
Public relations promotion	5,687.18		
Water works statistics	1,067.69		
Total Development Expense—Research		7,537.66	
Total Expenses			128,405.06
Net Income for the Year (Transferred to Exhibit C)			$ 5,022.05

* Denotes red figures.

EXHIBIT C—Surplus Account for the Year Ended December 31, 1946

Balance, January 1, 1946	$126,627.26
Add: Net income for the year, per Exhibit B	5,022.05
Balance, December 31, 1946, per Exhibit A	$131,649.31

Membership Statement—1946

	Active	Corporate	Associate	Honorary	Junior	Affiliate	Total
Total members, Jan. 1, 1946	4797	556	261	30	16	78	5738
Changes in membership grades	3	—	—	2	−4	−1	—
	4800	556	261	32	12	77	5738
Gains:							
New members during 1946	711	61	25	—	16	3	816
Reinstated during 1946	75	2	2	—	—	—	79
	5586	619	288	32	28	80	6633
Losses:							
Resignations and deaths	147	7	6	2	1	5	168
Dropped for non-payment	272	30	6	—	6	10	324
Total members, Dec. 31, 1946	5167	582	276	30	21	65	6141
Total members, Jan. 1, 1946	4797	556	261	30	16	78	5738
Gain in 1946	370	26	15	—	5	−13	403

Comparative Statement—Gains and Losses—19-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Non-payment of Dues	Gain or Loss	Total Members at End of Year
1928	203	36	99	126	+ 14	2456
1929	314	25	118	130	+ 91	2547
1930	501	39	122	134	+285	2831
1931	203	22	123	216	−114	2717
1932	117	22	169	297	−327	2390
1933	168	56	159	234	−169	2221
1934	271	66	86	122	+129	2350
1935	565	42	85	190	+332	2682
1936	311	53	104	218	+ 42	2724
1937	515	86	122	139	+340	3064
1938	520	59	144	140	+295	3359
1939	578	64	112	179	+351	3710
1940	514	58	113	212	+247	3957
1941	480	92	116	236	+220	4177
1942	570	59	132	233	+264	4441
1943	769	88	130	198	+529	4970
1944	734	92	140	171	+515	5485
1945	543	56	111	235	+253	5738
1946	816	79	168	324	+403	6141

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene* (*British*); *C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research* (*British*); *I.M.—Institute of Metals* (*British*).

HYDROLOGY

Irrigation. G. P. F. Boese. Civ. Eng. (Br.) p. 272 (July '46). Principles of irrigation same all world over, but methods and practice vary in accordance with climate, soil, crops, etc. Structures differ from large dams to small wooden outlets. Running and measurement of water, repair and renewal of structures, betterment work, etc. are of eng. nature and are carried out on larger projects by qualified engrs. Water quant. to be supplied detd. by expt. and meteorological records of locality, and system designed for avg. crops of area, also for stock and like needs, but not for human consumption, though after treatment and through wells such use of it frequently made. Irrigation water supplied by gravitation, pumping, or sprinkler systems and by various primitive devices still retained in some places. Other means of lifting water to higher levels include vertical water wheel operated by current of stream itself and hydraulic ram, automatic in operation and requiring liberal quant. of water under low head to raise water to considerably higher level. Area to be irrigated limited by water supply. Under favorable land features and finance prospects, water may be impounded by diversion dam at intake or in reservoirs away from stream. First step in irrigation project is survey to det. actual area to be watered, location of canals and calculation of water needed. This survey made by transit and level parties running alignment and profiles for canals and laterals and tying in all road crossings, water courses, railroads and buildings affected by scheme. Correct levels must be carried from some known datum and bench marks made, then plans and profiles prepd. to show parts to be irrigated, location of canals and laterals, canal right of way and structures necessary for control and regulation of water. Canals located along highest ground possible; lower lands must often be reached by droplines, flumes and chutes as well as open ditch, last being on contour grade with balancing cut and fill, and velocity maintd. that will not erode banks. Various means for control of water—diversion gates for branch canals, spillway gates for water release after priming or rain storms, siphons, etc., are all noted in article, together with costs, rotation of service and duty of water, that is, depth of water allowed per acre in given time. Excess water in irrigation may cause accumulation of alkali salts or water logging of land, these conditions being remedied by drainage.—*Ed.*

Water for Use in Irrigation. Valentino Morani. Avanguardia rurale, **14:** 3 ('43); Ann. staz. chim. agar. sper. Roma (It.), **17:** 5 ('43). A presentation of criteria and discussion of fitness of water supplies with particular regard to loading of soil with salts carried in by water. Water to be regarded as cold if its temp. is within 1° of $\frac{3}{4}$ the mean daily [air?] temp. at point of use. Let R be quotient of Na content in ppm. divided by Na + Ca + Mg; then if $R < 0.50$, water is tolerable; if $0.50 < R < 0.66$ questionable; if $R > 0.66$ water cannot be used. Alkali coeff. is another quotient or ratio defined as follows: if $Na - 0.65\ Cl \leqq 0$, then $K = 2040/Cl$; if $Na - 0.65\ Cl > 0$, then $K = 66.20/(Na - 2.6\ Cl)$; if $Na - 0.65\ Cl > 0.48\ SO_4$, then $K = 662/(Na - 0.32\ Cl - 0.48\ SO_4)$. When K as thus calcd. > 18, water is good; if $18 > K > 6$ it may be used with caution; if $6 > K > 1.2$, water dangerous; if $K < 1.2$ water must not be used. Oxidation-reduction

potential (rH_2) should be more than 15, which is about conversion point of methylene blue into leuco form.—*C.A.*

The Beginnings of Water Conservation. F. W. Robins. Wtr. & Wtr. Eng. (Br.) **48**: 652 (Dec. '45). Prototypes for most of man's devices found in nature, and, just as streams and rivers anticipated water distr. systems, so tanks, cisterns and reservoirs have natural counterparts in water-holes and river pools. Short of migration, first universal reaction of man, and sometimes also of beast, is to seek for water in place of last disappearance by scooping hole in old depression or in river bed. Selungs of Malaya, if unable to find stream, search for signs of underground water and scratch at foot of boulder until water seeps in. Search for water where it ought to have been was apparently method adopted by Elisha when he bade soldiers of Judah and Ephriam dig trenches in bed of wadi, which thereupon filled with water. Dinkas of Sudan, among other peoples dependent on water-holes, scoop out sandy bottoms in time of drought, and generally get otherwise natural depressions to refill by this means. Among Nuers of South Sudan, supply of water for villages obtained from excavations made at convenient spots nearby. In India, village tank or water-hole may have been excavated in first instance to provide building material for the settlement. By way of contrast, Hunzukuts of the Karakoram, though collecting water in stone-walled, open-air reservoirs for general purposes, carefully store drinking water in smaller dug-out pits, roofed over just above ground level and approached down steep steps, so no fear of poln. by animals. Large households in China, in addition to wells, sometimes had sunken tanks to collect water from roofs in drought. Gibralta relies for its water supply mainly upon catchment area formed by facing large surface of eastern slope with galvanized iron sheeting on which moisture-laden air ppts. water to flow into tanks below. In Syria and elsewhere in Near East, sinks and shallows in rocks serve as reservoirs, and in nearly rainless parts of Arabia such rain water as falls is collected in limestone cisterns. Troglodytes of Matmatas (Algeria) dependent on rainfall. "Cuvette" dug and pipe led from it to cistern let into earth, approached through narrow opening with sliding door made from half round of palm trunk. Treasured water protected from pilfering by cheap padlock on door. In arid plains of Ural provinces of Russia, inhabitants in past packed snow in underground chambers in winter for water storage, and in some districts of Montenegro snow also stored as water supply.—*H. E. Babbitt.*

Distribution of Heavy Rains in One and Two Hours. C. E. P. Brooks & N. Carruthers. Wtr. & Wtr. Eng. (Br.) **49**: 275 (June '46). Heaviest daily falls occur in intense thundery rains of relatively short duration. In any one climate max. rainfalls of 1 or 2 hours should have fairly consistent ratio to maxima in rainfall day. Investigation consisted of collecting all data that could be found for max. rainfalls in periods of order of an hour. (By "maximum" is understood "mean maximum.") Rainfall formulas used by different authors include: (1) E. G. Bilham: $N = 0.125T(R + 0.1) - 3.55$ (with N and T both variable), which reduces to: $R_{YH} = (7.5YH)^{0.28} - 0.1$; (2) R. W. Powell gives similar general form: $R_{YH} = c(YH)^{0.25}$; (3) C. Braak gives: $R_{Y(H)} = R_{2(H)}{}^{0.186}$. Eqs. 2 and 3 combined become: $\log R = a(\log H + \log Y) = c(I)$. Schumann gives: $I = a(\log Y + b)^{1.33}$. Reasonable and more simple expression is: $R_Y = a + b \log Y$. Nomenclature: R—rainfall in inches; I—rainfall, in./hr.; T—minutes; H—hours; Y—yrs. in which max. is expected once; N—number of falls of given intensity in one year. $R_{Y(H)}$—max. rainfall in fixed time H in variable years Y; $R_{H(Y)}$—max. rainfall in variable time H in fixed number of years Y. R_{YH} max. rainfall, Y and H both variable; a and b are coefficients. Relation between max. rainfall and time can be written $R_{H(Y)} = R_{1(Y)}(1 + \log H)$. By this expression ratio of mean max. rainfall in 2 hr. to that in 1 hr. is 1.3. Ratios of 1 hr. to 24 hr. max. in U.S. show steady increase from Pacific Coast (where ratio is 0.3) to about 105° E.; beyond that, ratios differ little from 0.5. Between 30° N. (lat.) and 30° S., max. rainfall in 2 yrs. can be represented closely by $0.8\sqrt{S}$ where S is mean annual number of thunderstorms. (All above has been used in prepn. of maps of world and of British Isles showing isohyets and isopleths of mean annual frequency of thunderstorms.—*H. E. Babbitt.*

The Flow of the River Nene. Anon. Surveyor (Br.) **105**: 349 (May 3, '46). Extracts from paper by R. F. Wileman and H. W. Clark before Inst. of Civil Engrs. Paper deals with measurements of dischg. of White Nile (Sudan) and Nene (Eng.). Of 4 methods

employed for gaging White Nile, in all of which current meters used, positions of boat are, in two, detd. by points marked on ropes stretched from bank to bank; in one permanent beacons erected and sextant used for fixing positions, and in fourth cross-river positions marked on bridge. Nene representative of British rivers as regards suitable gaging methods. Two current meters used are Gurley (U.S.A.) model 622 A W and Ott (Bavaria) model Mark V. Ott more reliable in turbulent water but Gurley-Price, if not used in turbulent water, preferable for ease of operation, maintenance and durability.—*H. E. Babbitt.*

Prediction of Frost Penetration. William L. Shannon. Civ. Eng. (Br.) **41**: 228 (June '46). Factors that influence depth of frozen soil are: (a) magnitude and duration of air temp. below freezing, (b) thermal properties of soil, (c) temp. conditions within soil at start and during freezing. Method for measuring combined magnitude and duration of air temp. below freezing, suggested by Casagrande, consists of plotting cumulative departures of temp. from 32° F. Difference between largest neg. and pos. value on plot termed "freezing index"; a measure of magnitude and duration of below-freezing temps. Greater its magnitude, greater frost penetration. Approx. value for index may be computed from monthly avg. temp. using formula: freezing index = $(32y - x)30.2$ in which y equals no. of months during which avg. temp. below freezing; x is sum of avg. temp. for these months; and 30.2 is avg. no. of days for Dec., Jan., Feb. and Mar. Value computed always less than true index but will approach it with increasing magnitude of index. Method should not be used where mean value of index less than about 300. Thermal properties of soils not extensively studied. Properties of frozen soil differs from unfrozen soil. Temp. conditions within soil at start of freezing influence frost penetration. Surface layer affects depth of frost penetration. Dark colored surface absorbs heat in daytime and radiates min. at night. Grass cover, leaves or snow may possess insulating qualities to reduce depth of freezing. Rigorous solution developed by Berggren, whose formula is: $x = 2B\sqrt{ta}$ in which x is frost penetration, t is time air is below freezing point of soil, a is thermal diffusivity of frozen soil (thermal conductivity divided by heat capacity), and B is function of thermal conductivity and heat capacity of soil, temp. conditions of air and soil, and latent heat of fusion of water in soil. Computations made by author indicate that Berggren's formula yields values approx. 50% greater than measured values. May be concluded that depth of freezing greatest in dry or moist sand or gravel. If ice segregation occurs in soil, resulting in increase in water content, depth of frozen soil reduced because of heat required to change temp. and freeze additional water. Believed possible to correlate freezing index with depth of frost penetration beneath snow-free areas in soils of similar thermal properties. Considered reasonable to base depth of water mains on conditions to be expected once in 100 years. At Portland, Me., all water mains laid in trench 5′ deep, regardless of size of pipe. 12″ pipe should have center exactly at computed depth of frozen soil; center of 24″ pipe 6 in. higher than computed depth of frozen soil. Few miles of large pipe, however, and water probably always in motion in them, so reasonable to conclude that larger mains may safely be placed closer to surface than smaller mains.—*H. E. Babbitt.*

The Surface Water Resources of Louisiana. Edward B. Rice. Louisiana State Univ. Eng. Expt. Sta. News **2**: 5 (Jan. '46). Starting in '38, resources being inventoried and recorded systematically at 63 gaging stations by U.S.G.S., with co-operation of the Louisiana Dept. of Public Works and assistance of U. S. Engrs., to encourage indus. development, advise on irrigation projects, drainage and flood control measures. Gaging stations mapped.—*A. A. Hirsch.*

Studies of Droughts in the Sydney Catchment Areas. F. W. F. Waitt. J. Inst. Engrs. (Australia) **17**: 90 (Apr.–May, '45). Drought of '34–'42 commenced when constr. work seriously behind schedule because of lack of finance. Severe restrictions on consumption caused great public interest in water supply. Definition of drought not simple. For water supply engr. drought is period of serious deficiency in runoff, commencing when storages cease to overflow and culminating when they reach lowest level. Length of drought depends on relation between consumption, storage and stream flow. From 1880 to '40 Nepean catchment area practically sole source of water supply for metropolitan Sydney. In '40 emergency supply constructed to bring water from Warragamba R., with catchment area of more than 3350 sq.mi.

Warragamba R. has practically ceased to flow for weeks at time, whereas on more than one occasion level has risen more than 90′ in flood. Percentage runoff varies greatly. On Nepean catchment area total runoff in May '43 was 83,300 mil.gal. (Imp.), while in 2 yr. '41 and '42 it was only 17,800 mil.gal. (Imp.). Correlation between rainfall and runoff found difficult. To decide storage required sufficient evidence not available to allow adoption of method of consumptive use, allowing for loss by evapn., transpiration, etc. Mass curve method of Ripple and Freeman most convenient method for those accustomed to graphic representation. Weakness of mass curve method is that, apart from reserve allowed, presumed that future droughts will be equal not only in magnitude, but in pattern, to those already experienced. For design of Warragamba Dam by use of mass curve method found that at certain storage, length of critical drought period changed suddenly from 3 or 4 yr. to about 8 yr., which gave sudden change in rate of increase of safe draft as height increased. Could not be expected that in future drought rains would again come at that particular stage. When drought characteristic curve used, length of critical period of drought increases steadily with increase of storage. Prepn. of drought characteristic involves more work than prepn. of mass curve, but gives for catchments of type under discussion more rational result, which is generally more conservative. If flow in stream has seasonal variation, curve of least runoff will tend to have sinuous shape, with period of approx. 1 yr. between successive greater points on curve. If rainfall and runoff result of chance, chance of occurrence next year of runoff equal to, or less than worst to be expected in 50 yr. would be same regardless of runoff this year. Fact is this year's runoff has influence on next year's. Occurrence of 2 very bad years in succession would be most unusual. Some rough measure of this can be obtained from deficiency curve. With storages on tributaries of same stream drought conditions usually similar. However, minor flood may cause smaller storage to overflow without refilling larger. On Nepean catchment, storage capacs. of reservoirs, measured in inches of runoff over catchment area, range from 10″ at Nepean to 59″ at Avon. While water supply requires conservation of water in drought, for hydro-elec. use may be profitable to use as much water as can safely be dischgd. By adapting characteristic curve, possible to det. at any stage of drought at what rate it is safe to deplete storage. Possibility of still more severe droughts anticipated by provision of reserve. Graphical development of method of statistician has been widely used for anal. of floods. Methods used by Hazen and Wilson not entirely applicable to such rivers as Warragamba and Nepean. If least runoff curve is drawn from 50-yr. records some points will be below normal expectation and some above. If distr. of magnitudes of monthly flows normal, would be possible to det. form of drought characteristic for any given probability of occurrence. If distr. of logarithms of flows in periods of any length can be taken as statistically normal distr., flows for any other probabilities will bear const. and calculable relationship to flows given by mean deficiency curve drawn from records. May yet be possible to est. probabilities by treating worst period of n months in certain calendar grouping, just as flood probabilities are calcd. from worst floods in each of series of calendar years. Statistical methods not readily applicable to conditions met on Sydney catchments, where stream flows not definitely seasonal and subject to great fluctuations.—*H. E. Babbitt.*

Water Plants in the Gezira Canals [Anglo-Egyptian Sudan]. F. W. Andrews. Ann. Applied Biol. (Br.) **32**: 1 ('45). Gezira cotton growing area in Anglo-Egyptian Sudan lies on west side of Blue Nile. Irrigated by system of canals, water being obtained from Sennar Reservoir on Blue Nile. During period Oct.–Dec. '37 survey made of aquatic plants in canals. Study of life histories of these plants made in exptl. canals. Found that abundant growth and formation of seed occurred when clear water entering canals. When water entering canals turbid most of vegetative parts of plants died but seed germinated. Drying canal bed for 3½ mo. had little effect on final quant. of weed developed when canal refilled. Seed survived exposure to sun for 3½ mos. Lab. expts. on 4 of more important plants showed that vegetative parts killed by dry exposure for 8 days. All 4 plants killed when immersed for 5 days in water contg. mercuric chloride, mercuric chloride-iodide, or sodium arsenite in concn. of 100 ppm. Work with poisons discontinued because those which killed plants were toxic also to man and animals and their use on large scale would be costly and might be unsuccessful. In one sec. of Gezira canal system, weeds removed by raking every

10-15 days to prevent formation of seed when water clear and every 15–20 days to remove seedlings during periods of flood. Control by this means has halved cost of clearance. Previously clearance undertaken only when stoppage of water occurred and abundant production of seed able to take place.—*W.P.R.*

River Valley Planning in India: The Damodar. MERRILL R. GOODALL. J. Land & Pub. Util. Econ. **21**: 371 (Nov. '45). Planned development of land and water resources of entire river valley by TVA and Bureau of Reclamation aroused world-wide interest esp. in India, where conditions similar to Tennessee exist in many river basins. Article reports planning of project in one river basin and states administrative problem to solve. Bengal is deltaic country, product of Ganges, Damodar and Brahmaputra. Damodar valley, area 9000 sq.mi., is west of Calcutta. Damodar river wide, shallow with steep slopes, alluvial, carrying much silt. River bed high, ever building; levees promise no solution. Key to problem is distr. of rainfall in monsoon months. Mean annual pptn. of Damodar valley 24 mil. acre-ft.; 19 mil. acre-ft. fall in upper reaches with 55 to 85% runoff, in lower valley 15 to 20% runoff. During monsoon June to November river flows 30,000 cfs., rest of year 1600 cfs. Solution of problem calls for detention of percentage of runoff by dams in upper Damodar and Barakar regions and series of barrages in lower reaches for distr. by irrigation. Design of project intended to meet minimum requirements for flood control, irrigation supply, power generation, and provision for navigation. Fall of 1715′ in river's length available for hydroelectric power if storage dams built at suitable sites. Upper basin of Damodar could provide 488 mil. kwhr. with 6 storage reservoirs. Lower Barakan basin could provide 453 mil. kwhr. with 5 storage reservoirs. Storage capac. of all dams 2,270,000 acre-ft. If all dams constructed 30% of runoff could be stored. Estd. expenditure of $100,000,000 would yield $6,000,000 annually from power sales. Need for power in Damodar valley for coal mines, bauxite deposits, calcium nitrate, calcium carbide and cities. About 3500 sq.mi. of upper Damodar basin bare wasteland, 2000 sq.mi. under cultivation. Bare areas wash off and rivers carry heavy load of silt and sand. Soil conservation program needed to lengthen life of dams. Creation of Damodar Valley Authority urged but co-operation needed in overriding provincial barriers. Central Indian govt. has no authority to order project constr. Projects prepared in provinces because water resources are provincial subject according to law. DVA involves 2 provinces, so agreement unlikely. Neither province has necessary technical resources. Central Indian govt. recently created advisory boards to help solve water problems involving more than one province. Before any river valley can be fully developed co-operative arrangements must be maintd. between provinces and Central Indian govt.—*A. C. Rener.*

Afforestation on Gathering Grounds. J. ARTHUR RODWELL. Surveyor (Br.) **104**: 599 (Oct. 12, 45). County of Durham fortunate in having within its borders sources of water of excellent qual. ample to meet all needs if provision made for storage. Care has to be taken in impounding these waters because, owing to nature of ground and "flashy" nature of streams, water contains considerable amt. of matter in suspension and is subject to discoloration difficult to elim. During flood much valuable water lost because of need for diverting quants. away from reservoirs. Only alternative is to allow water to enter reservoirs and this causes considerable overloading of filters. As means of counteracting this, afforestation being developed. Has been asserted that masses of woodland tend to increase rainfall. Rain which reaches ground in afforested region better conserved than rain falling on non-afforested area. In addn. to this, greater humidity of air in wooded areas and absorbent and retentive character of vegetable matter that covers ground better fitted to discourage evapn., as well as to impede runoff. Retardation of runoff has greater effect; it prevents violent freshets and erosive floods such as are responsible for turbidity of streams and silting up of reservoirs. Such water need not be by-passed. Saving of water effected, as during summer storms, when often needed most. Snow, too, so valuable as reserve during early spring months, frequently melts with such suddenness that snow water charged with mud and has to be allowed to run to waste. Under trees it melts more slowly than in open, so that at time of thaw its yield is more gradual. Trees tend to equalize temp. of water and have lowering influence on mean annual temp., and temp. of water running off afforested areas slightly raised in winter, but markedly lowered

in summer. Bacteriologists assert that forests exercise purifying influence on both air and soil. Water of reservoir sheltered by well-grown woodland comparatively free from violent agitation by gales, which otherwise would stir up mud and silt along banks. Impossible to est. financial benefit to be derived from these results, nor can esthetic value of well-planted woodland be expressed in terms of pounds, shillings and pence, but it is certain that there is every reason to believe that afforestation in itself will prove profitable investment. Two distinct classes of trees present themselves: (a) deciduous—mainly hardwoods and conifers—and (b) common softwoods—spruce, larch, firs and pines. Hardwoods have adaptability to climate and greater selling value. Soft woods have comparatively rapid growth. Planting of hardwoods on these islands not looked upon as good commercial proposition, whereas soft woods have, of late years, found general favor. Of minor importance is aesthetic value created by judicious planting.—*H. E. Babbitt.*

Irrigation in Algeria. Ten Large Algerian Dams. Michel Raineau. Wtr. & Wtr. Eng. (Br.) **47**: 466 (Oct. '44). Flow of Algerian rivers irregular, varying from torrents to dry beds. None is navigable. About 20 yr. ago Algeria initiated agric. policy based on large-scale irrigation of land. As early as '30, 10 large dams had been constructed. Largest is Ghrib Dam which impounds River Cheliff. Dam 885′ long at base and 213′ high. It stores 280 million cu.m. Spillway can dispose of 4000 cu.m./sec. Oued Fodda Dam 140 mi. west of Algiers. It is 295′ high. It impounds 282 million cu.m. of water. With exception of Bou-Hanifia Dam, which stores 75 million cu.m. of water, remaining dams considerably smaller. Water distributed through open aqueducts or reinforced concrete pipes. Several dams have hydro-elec. power stations. 10 dams cost £5,000,000 to £6,000,000.—*H. E. Babbitt.*

Water for the Thirsty Lands of Mexico. Adolfo Orive Alba. Wtr. & Wtr. Eng. (Br.) **47**: 160 (Apr. '44). Phys. and agric. characteristics of Mexico show country to be roughly divided into 3 main zones: (1) central or high plateau region, (2) tropical zones of Gulf and Pacific Coast, and (3) northern zone. Main agric. problem is to develop irrigation in dists. where people from impoverished and densely populated region of central high plateau may be moved. In '26 Mexican govt. constituted Mexican Com. of Irrigation, which, in past 17 yr., has improved 750,000 acres of land. New works will irrigate area of approx. 1,750,000 acres. By '32, Mexican engrs. able to carry out irrigation works by themselves on lines comparable with U.S. engrs.—*H. E. Babbitt.*

STERILIZATION

Studies on the Mode of Action of Compounds Containing Available Chlorine. H. C. Marks, O. Wyss & F. B. Strandskov. J. Bact. **49**: 299 ('45). Expts. have been made to det. factors to which bactericidal action of *N*-chloro compds. due. In aqueous soln. action of *N*-chloro compds. may be partly or wholly due to hypochlorous acid or hypochlorite ion produced by hydrolysis. In expts. dil. aqueous solns. with pH value between 4 and 9 used so that concn. of dissolved molecular chlorine would be insignificant; assumed that rate of hydrolysis greater than rate at which hypochlorous acid used in killing organisms. Organisms used were *Esch. coli* and spores of *Bacillus metiens*. Nitrogen compds. used were 3,5,5-trimethylhydantoin, *N*-methyl-*p*-toluene-sulfonamide, and piperidine. Exptl. procedure described. Study of bactericidal properties of hypochlorous acid has shown that variation of death rate with pH value is such that it can be assumed that undissociated hypochlorous acid active agent and that hypochlorite ion inactive. Thus action of *N*-chloro compds. will depend on extent of hydrolysis and on pH value. Apart from hydrolysis to hypochlorous acid unhydrolyzed molecule of *N*-chloro compds. may itself be toxic. For these expts. therefore stable compds. used which were capable of forming only monochlor compds. to elim. toxicity due to change in ratio of chlorine to nitrogen. When stoichiometric proportions of nitrogen and chlorine present found that bactericidal action due entirely to small amt. of hypochlorous acid present. When amt. of nitrogen present increased bactericidal activity decreased corresponding to reduction in concn.

of hypochlorous acid produced by displacement of hydrolysis equil. After certain point further increase in concn of nitrogen produced no further change in bactericidal activity; assumed that at this stage concn. of hypochlorous acid negligible and that activity due to unhydrolyzed *N*-chloro compd. itself. Detn. of hydrolysis constant, on which activity of *N*-chloro compds. depends, has been difficult. Effect of pH value on action of dichloramine-T and halazone on spores of *B. metiens* detd. Increase in rate of killing up to pH value of 7 can be attributed to increase in concn. of hypochlorous acid as result of displacement of hydrolysis equil. At pH values above 7, bactericidal activity less because of increased ionization of hypochlorous acid.—*W.P.R.*

Treatment With Chlorine Dioxide. W. D. MacLean. Wtr. & Sew. **84**: 5: 21 (May '46). ClO_2, with 2.5 times oxidizing power of Cl, effective for taste destruction. Unstable gas and must be generated at point of application. Soln. of $NaClO_2$ fed into reaction generator with dischg. from chlorinator in proportion by wt. of 0.8 Cl:1 $NaClO_2$, which is twice theoretical amt. of Cl. Higher ratio may be employed if necessary to satisfy Cl demand. pH of Cl soln. must be between 2 and 4; i.e., must contain 250–500 ppm. Cl. As ClO_2 reacts actively with contaminants, more economical to satisfy Cl demand with Cl and reserve ClO_2 for taste destruction. Residuals more persistent than with Cl. ClO_2 does not react with NH_3 to form chloramines. Once proper dosage and point of application detd., min. amt. of control provides continuously safe and palatable water. Lindsay, Ont., supply, from slow-moving river draining marshy lake, contains considerable decaying org. matter and algae and taste objectionable at all seasons, especially late summer. Cl, 3.5 ppm., and $NaClO_2$, 0.4 ppm., applied prior to pressure filters, give 0.3 ppm. residual after filtration and eliminate odor. Optimum results when ClO_2 applied at least 4 hrs. before water reaches first consumer. Use of ammonium sulfate and C discontinued. At New Toronto, phenols and algae troublesome in L. Ontario water. Cl applied in mixing basins and 0.25–0.3 ppm. $NaClO_2$ in settling basins eliminates all taste and odor and gives 0.25 ppm. residual in plant effluent, latter persisting longer than with Cl alone. NH_3 and Cl discontinued. Scarborough Township plant, treating L. Ontario water, has taste and odor problem caused by sewage pollution. $NaClO_2$, 0.3 ppm., applied after filtration, plus 25% less Cl than formerly used corrects taste and odor and gives higher residual. Over-all cost for taste and odor control almost halved. Water supply of Wallaceburg from river polluted with industrial wastes causing chlorophenol tastes. ClO_2 applied to suction of high-lift pumps destroys taste in less than 5 min. Phenol tastes more easily controlled (less ClO_2 required) by first converting to chlorophenol by pre-chlorination. Cl residual of 0.1 ppm. in tap water 4 hrs. after leaving plant. Camrose, Alta., supply, from impounding reservoir fed by small creek gathering runoff from farm land and pasture, contains high concn. of org. material and algae. Chem. dosages formerly employed: Cl 9–14 (free residual), alum 90–180, C 9–15 ppm. $NaClO_2$, 0.4 ppm., with sufficient Cl to more than satisfy normal Cl demand effects decided improvement and indications are that over-all chem. cost approx. $\frac{1}{6}$ less, principally through discontinuance of C application.—*R. E. Thompson.*

Sterilization of Water Supplies. W. J. Marshall. Wtr. & Sew. **84**: 8: 15 (Aug. '46). Method used for many yr. in Maritime Provinces for treatment of industrial supplies and at 3 municipal plants—Fredericton, N.B.; Bathurst, N.B.; and Kentville, N.S.—consists of producing alumina floc by means of Al electrodes and Ag ions by Ag electrodes, casings of equip. being cathode. Film of alumina deposited on latter prevents plating out of Ag^+, which is retained in floc on surface of sand filters. Where bactericidal water desired, second Ag anode placed in filter effluent line. For sea water, as in fish-processing plants, C electrodes substituted for Ag, resulting Cl effecting disinfection. Direct current employed, voltage being 1.6 and amperage varying from 0.02 for sterilization up to 10 for producing bactericidal water. Current cost varies from 0.1 to 1.5¢ per ton.—*R. E. Thompson.*

Progress in the Treatment of Water for Taste and Odor Correction. Norman J. Howard. Wtr. & Sew. **84**: 11: 14 (Nov. '46). Superchlorination successfully employed at Toronto since '27. Addnl. cost originally **$0.72** per mil.gal. (Imp.) but now less than **$0.50** owing to lower cost of Cl and improved raw water. That free residual Cl contents will not cause complaints of taste has not been confirmed in Toronto. Moreover, high residuals may

cause difficulties in certain manufacturing processes. ClO_2 has been reported upon favorably as taste-destruction agent but not as effective as Cl as germicide, except in water relatively free from org. matter. Activated C increasingly applied to raw water and to reservoirs. In some cases, more effective than $CuSO_4$ for problems due to algal growths. Chloramines somewhat less widely used, possibly due to lag in disinfection rate.—*R. E. Thompson.*

Sterilization of Small Water Supplies. L. Louis & F. Farr. Bul. Ind. State Bd. Health, **47**: 132 ('43). Necessity for disinfecting new wells before use and old wells which have been repaired, flooded or suspected of direct contamn., emphasized. Before attempting to disinfect new well, water should be pumped to waste for several hours. Powd. chlorine of lime recommended for disinfection but satisfactory results can be obtained with bleaching solns., such as used in laundries, provided that amt. of available chlorine known. For bored well of diam. 6″ or less, $\frac{1}{4}$–$\frac{1}{2}$ lb. of fresh chloride of lime or 6 pints of bleaching soln. contg. 1% available chlorine required for every 100′ of depth of well. Various methods for cleaning contamd. dug wells described. For each ft. of depth of dug well, $\frac{1}{4}$ lb. of chloride of lime should be used for wells of diam. 1–5′, $\frac{1}{2}$ lb. for wells of diam. 6′–7′, and 1 lb. for wells of diam. 8–10′. In all wells water should be allowed to stand for 24 hr. after addn. of chlorine and should then be pumped to waste until taste and odor of chlorine no longer noticeable. Sample of water should then be sent to lab. for bact. anal. If it is likely that piping to house has been contamd. in addn. to well, pipes should be flushed and chlorinated water from well should subsequently be pumped through them.—*W.P.R.*

Prechlorinating Delaware River Water Aids Filtration. Torresdale, Philadelphia, Pa., Plant Treats Highly Polluted Water and Prechlorination Has Shown Numerous Advantages in Filter Operation. Martin J. McLaughlin (Torresdale Filter Plant, Philadelphia, Pa.). W. W. Eng. **98**: 1492 ('45). Chlorination of settled raw Delaware R. water makes it possible to use raw water having much higher coli count than formerly considered good practice. Other advantages include improved coagulation and improved pptn. of Fe and Mn, oxidation of H_2S and similar compds., and control of algae and other organisms and of slime growth in basins and filters.—*C.A.*

Emergency Sterilization of Drinking Water With Heteropolar Cationic Antiseptics. J. F. Kessel & F. J. Moore. Am. J. Trop. Med., **26**: 345 (May '46). Although there are many practical uses of antiseptics which are effective against cysts of *Endameba histolytica*, one of most important and difficult is emergency sterilization of drinking water under combat conditions. Various halogen prepns. have not been entirely satisfactory because they tend to be inactivated by org. nitrogenous material and by alky. Since natural waters encountered in field may sometimes contain very high concns. of org. nitrogenous material or may be alk., and since military emergency conditions in the field require uniform dosage, necessary to use halogens in high initial concns. under all conditions so that they may prove effective even under worst conditions. These high concns. of halogens distasteful and may not be entirely without toxicity. Expts. have indicated that certain heteropolar cationic compds. such as Roccal (alkyl dimethyl benzyl ammonium chloride, also known as Zephiran), Phemerol ([*p*-octyl phenoxy ethoxy ethyl] dimethyl benzyl ammonium chloride), Ceepryn (1-*n*-hexadecyl 2-methyl pyridium bromide), and many others capable of killing amebic cysts in dilns. of 1:10,000 with densities as high as 10,000 cysts per ml. when exposed for 10 min. at 20°C. These drugs remained bactericidal over wide pH range. There are, however, 2 principal problems involved in their use for sterilization of drinking water. They have definite and slightly unpleasant taste in effective concns., and these concns. have not been examd. sufficiently to demonstrate their complete lack of toxicity when consumed over prolonged periods of time by man. Further studies are being made in effort to find some method for inactivation of excess antiseptic after its antibiotic action has taken place. Cysticidal activity of heteropolar cationic antiseptics suggest consideration of their use for other purposes, such as decontamn. of dishes, fruits, vegetables, clothing and pre-operative skin areas.—*Ed.*

Water Supply for the Stilwell Road. C. W. Christenson. Public Works, **77**: 19, 40 (Apr. '46). In spite of ample water availability many difficulties encountered due to

local customs, untrained personnel, and prevalence of amebic dysentery. Further difficulty was that 50,000 troops scattered in varying concns. over distance of 467 mi. Supplies very slow in arriving and very often arrived in bad condition. First troops in area followed practice of boiling water 20 min. for purif., following orders of medical officers. Considerable difficulty encountered in convincing medical officers of merits of filtration and chlorination for control of amebic cysts. Check on boiled water showed 15–30% of all samples nonpotable or questionable. This contrasts with only 2½% nonpotable samples from otherwise approved supplies. Sources of supplies deep and shallow wells and streams. Efforts made to protect wells against contamn. and provisions made for chlorinating all approved supplies. Semiportable, knock-down purif. units installed in several localities and produced very satisfactory water as long as they were operated by trained personnel. Only one mobile purif. unit installed because of shortage of equip. and personnel. Portable purif. units found inadequate for problems encountered. Super-chlorination and de-chlorination practiced at one location and considered to be of such merit as to warrant much wider application. Author suggests greater utilization of shallow wells and greater forward planning by Army for solving such problems.—*P.H.E.A.*

Chlorine as a Possible Ovicide for *Aedes aegypti* Eggs. STEPHEN P. HATCHETT. Pub. Health Rpts. **61**: 683 (May 10 '46). Author conducted expts., using chlorine as possible ovicide, on *Aedes aegypti* eggs that were approx. 2 days old before treatment began or before they were dried. In one series 75 eggs placed in jars contg. various portions of freshly prepd. calcium hypochlorite solns., immediately after 48-hr. incubation period. In second series eggs dried for 96 hr. after 48-hr. incubation period, and 100 of them placed in jars contg. various concns. of available chlorine. Results indicate "that newly prepd. solns. of calcium hypochlorite contg. 50–100 ppm. of available chlorine effective ovicides for both continuously wet and previously dried *Aedes aegypti* eggs." In this way chlorine may be used as ovicide in buckets or barrels used for fire protection purposes and in similar instances where water stored for purposes other than drinking. It might also be used in drinking water containers, before dumping and replacing water, to induce eggs on sides of containers to hatch and then be destroyed.—*P.H.E.A.*

STREAM POLLUTION CONTROL

The Protection of Raw Water Supplies. A. E. BERRY. Eng. Cont. Rec. **59**: 3: 78 (Mar. '46). Surface waters plentiful in Ontario and many other parts of Canada. Freedom from excessive contamn. therefore foremost problem. Sewage treatment has not kept pace with reasonable demands; industrial activity has increased and become concd. in certain areas; and lack of water conservation measures has resulted in low stream flows during warm season. Coincidently, consumers demanding higher standards of water quality. Imperative that poln. prevention be considered. In '13, Interntl. Joint Com. adopted std. of 500 *Esch. coli* per 100 ml. (annual avg.) for boundary waters between U.S. and Canada, and later U.S. Public Health Service established coliform density of 5000 per 100 ml. as approx. limit of tolerable raw water poln. Stds. adopted for surface waters used for bathing vary from 50 to 1000 *Esch. coli* per 100 ml., and quality higher than that indicated by latter figure widely accepted as satisfactory. For streams not used for domestic supplies or bathing, aesthetic considerations and prevention of septic conditions most important criteria of poln. Poln. surveys, conservation schemes and sewage treatment programs necessary. Only combination of raw water protection and adequate water treatment can solve water quality problem.—*R. E. Thompson.*

Waste Water Disposal in Los Angeles Basin. WALLACE A. SAWDON. Petrol. Engr. **15**: 3: 55 ('43). Salt water produced along with oil either taken care of locally or transported to one of 3 central separating plants, one of which (Santa Fe Springs Waste Water Disposal Co.) described. Water aerated, settled, treated with $Al_2(SO_4)_3$ and acidified Na silicate, and filtered. About 100 bbl. oil per day recovered. Effluent has 50 ppm. max. turbidity, 1 ppm. max. H_2S and no objec-

tionable odor. Piped through 15 mi. of vitreous pipe emptying into ocean inlet. Both inlet and outlet pipe have to be scraped frequently to remove hard scale clogging pipe and fixtures.—*C.A.*

Aerating a River to Reduce Pollution. Eng. News-Rec. **136**: 416 ('46). Expts. on re-aeration of river water made over period of 2 yr. on stretch of Flambeau R. in Wisconsin, which was pold. by waste sulfite liquor from mfr. of cellulose. Air diffusers placed in tail race at power station about ¾ mi. below pulp mill. During periods of low flow in '45 content of dissolved oxygen in river maintd. at or above 3 ppm. at point 18 mi. below pulp mill. Efficient application of method limited to streams where content of dissolved oxygen falls below 4 ppm.; when concn. higher further oxygen dissolved only slowly.—*W.P.R.*

Toxicity to Rainbow Trout and Minnows of Some Substances Known to be Present in Waste Water Discharged to Rivers. J. Grindley. Ann. Applied Biol. (Br.) **33**: 103 ('46). Time-mortality data on 9 compds. tested against rainbow trout (*Salmo gairdneri* var. *shasta*) and minnows (*Phoxinus phoxinus*) together with temp., pH, and in some cases dissolved O in parts per 100,000 of test solns., presented. $NaAsO_2$ more toxic than Na_2HAsO_4 to *P. phoxinus*; limiting concn. not detd. Na dinitrophenolate much more toxic than Na picrate to this species; limiting concn. for both compds. probably about 30 ppm. $ZnSO_4$ at 25 ppm. Zn killed *S. gairdneri* in 133 min.; $K_2Cr_2O_7$ more toxic than K_2CrO_4. In solns. of these salts at pH less than 5.0, toxicity due in part to acidity. When data plotted with concn. in ppm. Cr as x, and 100/(time in mins. before fish loses equil.) as y, curve for K_2CrO_4 linear while that for $K_2Cr_2O_7$ had initial steep slope, followed by more gradual slope and final upward sweep. Limiting concn. for these compds. slightly less than 20 ppm. Cr. NH_4Cl and $(NH_4)_2SO_4$ more toxic to *S. gairdneri* in hard water (pH 6.5–7.8) than in distd. water (pH 5.2–6.3); limiting concn. probably slightly less than 100 ppm. NH_3.—*C.A.*

Treatment and Disposal of Waste Waters Containing Chromate. J. Grindley. J. Soc. Chem. Ind. (Br.) **64**: 339 ('45). Work on treatment and disposal of waste waters contg. chromium undertaken as part of program of Water Pollution Research Board of Dept. of Scientific and Industrial Research. Waste waters contg. chromate produced in chromium plating of metals, anodic oxidation of metals and prepn. of metal surfaces before electroplating and assembly of components. Usually acidic and contain in addn. to chromate, sulfuric acid and salts of zinc, copper, aluminum and nickel. Free acid, chromate, and heavy metals toxic to fish and to organisms on which fish feed. Dischg. of waste waters to sewage works may have deleterious effect on materials of sewers and works and on sewage treatment. Spent solns. contg. high concns. of chromium should not be dischgd. to surface waters or to sewers; there are firms which collect such liquids for recovery of chromium. Concn. of chromium in waste washing water usually too low to make recovery of chromium profitable, and it must therefore be treated before final discharge. In tests described, waste water from factory engaged in tin plating and assembly of components of radiators used. In most of tests waste water dild. with about 9 times its vol. of distd. or demineralized water to give concn. of chromate equivalent to about 20 ppm. chromium. Tests made on reduction of sexavalent to tervalent chromium by means of scrap steel or ferrous sulfate. When waste water in stationary contact with steel turnings and initial pH value of waste water 3 or less, chromate completely reduced in 1 hr.; when initial pH value 4, in 2 hr. In solns. contg. chromic acid in concn. of about 530 ppm. chromium, reduction of chromate very slow and it seemed probable that surfaces of turnings had become passive. In tests in which waste water made to flow at rate of 6 l./hr. through 2 tanks contg. steel turnings and in which avg. period of contact of turnings with waste water 4 hr., concn. of chromate reduced from about 20 ppm. to 4.3 ppm. chromium when pH value of untreated waste water 3.0–3.1. In one test with waste water which had pH value of 2.8 and contained 24.0 ppm. chromium, only trace of chromium remained unreduced after being in contact with steel turnings in tanks for 3 hr. Concluded that treatment of waste water contg. chromate with steel turnings practicable only for distinctly acid waste waters contg. little chromate; this method could be used where acid waste waters available which could be mixed with waste water contg. chromate. When ferrous sulfate in amt. theoretically required to reduce chromate to tervalent condition dissolved in waste water which contained 21.5 ppm. chromate (as Cr) and which had pH value of 4.1, concn. of

chromate reduced to 0.007 ppm. chromium when mixt. allowed to stand for 19 hr. When twice theoretical amt. of ferrous sulfate used, period of contact required to reduce all chromate less than ½ hr. when initial pH value of waste water 4.1, and less than 1 hr. when initial pH value 4.9, 5.0, 6.9 or 10.0. Chromic acid in concn. of about 530 ppm. chromium completely reduced in 1 hr. by theoretical amt. of ferrous sulfate. Concluded that ferrous sulfate suitable for treating both acidic and alk. waste waters contg. chromate. Cost of ferrous sulfate for treating waste water contg. 20 ppm. chromium would be about 3d./1000 gal. After reduction of chromate liquor would be treated with milk of lime to ppt. chromium and other heavy metals. Tests also made on treating waste water contg. chromate with witherite, which contains between 92 and 95% barium carbonate. Complete pptn. of chromate achieved by stirring samples of waste water contg. from 20–278 ppm. chromium for 1 hr. in admixt. with large excess of witherite at temp. of about 20°C.; pH values of treated water varied from 6.9–7.4. When treated water allowed to stand for 2 days, supernatant liquor cloudy; but, after further period of 2 days, clear and colorless. When 0.70 g. of aluminum sulfate ($Al_2SO_4)_3 \cdot 18H_2O$) added to 28 l. of treated water which had been allowed to stand for 24 hr., supernatant liquor clear after further period of quiescence of 7 hr. In another test to det. whether cations of chromium could be removed from soln. by witherite, soln. contg. 20.5 ppm. chromium potassium sulfate (as Cr) stirred for 1 hr. with large excess of witherite. Suspended matter settled rapidly from mixt. Filtered sample of treated liquid contained no chromium. To det. whether witherite would remove zinc and copper as well as chromium from soln., synthetic waste water contg. 21.0 ppm. chromate (as Cr), 25.0 ppm. zinc, 4.0 ppm. copper, and 43 ppm. sulfate (as SO_4) stirred for 1 hr. with witherite. After mixt. had been allowed to stand for 5 hr., supernatant liquid almost free from suspended matter and contained 0.8 ppm. chromium, no sulfate, about 1 ppm. barium, 22 ppm. zinc, and 1.2 ppm. copper. When excess of Rema pulverized witherite 99.75% of which will pass through 240 bottom settlings sieve, used to treat successive 30-l. batches of waste water contg. 27.8 ppm. chromate (as Cr) and 5 ppm. sulfate (as SO_4); almost all chromate removed from first 3 batches but only 24% from 4th batch. Amt. of witherite present for treating 4th batch 7 times amt. theoretically required to ppt. all chromate and sulfate; incompleteness of reaction might have been due to coating of barium chromate and barium sulfate on witherite. About ⅓ of witherite originally present had been used. In similar test with Normal pulverized witherite, 95% of which will pass through 200 B.S. sieve, about ½ of witherite used to ppt. chromate and sulfate. Concluded that it was more economical to use finer grade of witherite; cost of witherite required to treat 1000 gal. of waste water contg. 200 ppm. chromate (as Cr) and 5 ppm. sulfate (as SO_4) would be between 3d. and 4½d. Waste water contg. 21.5 ppm. chromate (as Cr) passed successively through beds of Zeo-Karb and Deminrolit B at rate of 2.7 l./hr.; chromate not detected in treated water until 740 l. had passed through beds. When 900 l. had been treated effuent contained 0.22 ppm. chromium. Test then stopped. Only small proportion of chromium absorbed by beds recovered when both beds treated with solns. of hydrochloric acid and ammonium hydroxide. From Zeo-Karb 1.48 g. of chromium recovered as chromium chloride and none as chromate. From Deminrolit B 1.10 g. of chromium as chromate and 0.24 g. as chromium chloride recovered. Concluded that these ion-exchange materials unsuitable for treating waste water contg. chromate because they could not be regenerated in simple way. Tests made on toxicity of chromium to fish. Concns. of 20 ppm. chromium in form of potassium chromate or dichromate killed rainbow trout in from 2–8 days. Rainbow trout appeared to be able to withstand slightly less than 20 ppm. chromium in neutral soln. for 8 days. Waste water treated with steel or ferrous sulfate, and then with lime, had no apparent effect on minnows immersed in it for 2 days. Some samples of waste water treated with witherite were toxic to rainbow trout and toxicity could be accounted for by zinc and copper present. Satd. solns. of barium carbonate had no adverse effect on trout. Waste water which had been passed through Zeo-Karb and Deminrolit B not toxic to minnows.—*W.P.R.*

A Paperboard Mill's Attack on Stream Pollution. T. E. Brookover. Paper Tr. J. TAPPI Sec. 95. **120** ('45). Methods adopted by Downingtown Paper Co., Downingtown, Pa., to prevent loss of fibre and to prevent poln. of streams by waste waters from paperboard mills described. In '24 Bird save-all

installed and still in use; amt. of suspended solids removed by save-all varies from 0 to 75% and depends upon ratio of long to short fibres in waste water. Save-all can no longer deal with total flow of waste water. In '30 Link-Belt sedimentation unit installed to treat waste water from 2 adjacent mills. Purpose was to recover suspended solids for re-use in filler stock, to obtain fairly clear white water for re-use and to reduce poln. of stream to which waste waters dischgd. Unit comprises 4 similar tanks operating in parallel; each tank 55′ long, 16′ wide and 10′ deep, and equipped with 12 scraper bars which move on surface of liquid towards outlet end of tank and along bottom of tank towards inlet end. When total flow 1.0–1.5 mgd. and no coagulant added, avg. removal of suspended solids in tanks 66% in '39–'41 and 84% in '44. Waste water from third mill mixed with effluent from Link-Belt sedimentation unit; after part of combined waste waters has passed through Bird save-all it contains fine suspended and colloidal matter but few long fibres. In '37, 2 final sedimentation tanks, operated in parallel, built; each tank 400′ long, 7′ at max. depth, 60′ wide at top and 40′ wide at bottom. Theoretical period of retention 24 hr. but dye tests have shown that water passes from inlet to outlet in 1 hr. Alum alone gave better results than alum used in conjunction with carbon, lime, or soda ash, or than ferric sulfate for treating water in final sedimentation tanks. Optimum dose of alum 103–137 ppm. Effluent contains 4–60 ppm. suspended solids. Treatment with alum reduced B.O.D. of waste water from 54–415 to 13–200 ppm. and also reduced concn. of volatile dissolved solids. Final sedimentation tanks must be cleaned every 3–5 mo. After water drained from tank, sludge broken up by water from hose and then pumped to sludge tank where allowed to settle. When sludge tank full, sludge removed and dumped. Accelerator has now been installed before final sedimentation tanks. Results obtained have not always been good because load of solids on Accelator often 4 times greater than load for which designed. After it has been cleaned, Accelator has produced effluents contg. less than 30 ppm. suspended solids.—*W.P.R.*

Pollution Control in Streams in the Sudeten Region. R. Weber. Dtsche. Wasserwirtschaft (Ger.) p. 23 ('42); Wasser u. Abwasser (Ger.) **40**: 62 ('42). Stream conditions poor because of low water flow, large pop. and intense industrialization. Establishment of central purif. plants under professional supervision for treatment of both domestic and indus. sewage suggested.—*C.A.*

Means of Purifying Water Naturally. Spitta. Gas-u. Wasser (Ger.) **83**: 293 ('40). Literature on importance of bacteria, protozoa and bacteriophages in self-purif. of water surveyed. Bacteria play considerable part in all processes of self-purif. Water which has been naturally purified usually contains relatively few bacteria because decompn. of org. matter in water has resulted in lack of food for bacteria. This decrease in numbers of bacteria in surface waters usually more rapid in summer than in winter. J. Smit found that decrease in numbers occurs first among pathogenic bacteria in following order: *Bact. typhosum* and *Bact. paratyphosum*, fecal streptococci, strains of *Esch. coli* giving pos. Eijkman reaction and other coliform bacteria. Types of bacteria limited to specific substances for their nutrition disappear first; most pathogenic organisms of such types. Diln. of river water by ground water contg. few bacteria may cause apparent decrease in number of bacteria. In slowly flowing or standing water, bacteria, especially those adhering to heavy particles of polg. matter, removed by sedimentation. Bactericidal effect of light, particularly ultraviolet light, must not be disregarded but should not be overestd. Protozoa of importance in self-purif. of water because they feed on bacteria. Several workers have shown that they consume bacteria not normally present in unpold. water, including coliform bacteria, rather than those usually occurring. Role of protozoa in activated-sludge process of sewage treatment discussed. Div. of natural waters into oligotrophic and eutrophic types described. In rapidly flowing streams contg. much dissolvd org. matter, in spite of abundance of oxygen, sewage fungi, such as *Sphaerotilus natans* and *Leptomitus lacteus*, develop and their decompn. may cause secondary poln. of water. Under certain circumstances filtration of surface water through soil removes all bacteria. Discovery and present knowledge of bacteriophages described. Sewage is most productive source of bacteriophages. Method for detecting bacteriophage in water described. Disagreement as to value of presence of bacteriophages as indication of poln. and as to role of bacteriophages in self-purif. of water. 35 ref.—*W.P.R.*